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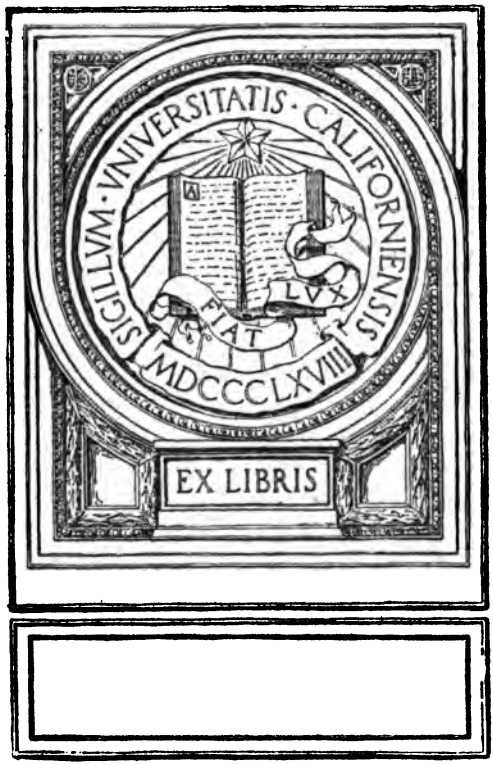
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MODERN MANAGEMENT
APPLIED TO CONSTRUCTION

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MODERN MANAGEMENT
APPLIED TO
CONSTRUCTION

BY

DANIEL J. HAUER

CONSTRUCTION ECONOMIST; CONSULTING ENGINEER.

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"In American business life there has arisen almost a hue-and-cry for methods of higher efficiency."—Benjamin A. Franklin.

THIS VOLUME IS INSCRIBED BY
THE AUTHOR

TO ONE WHO, SCHOOLED ONLY IN THE WORLD OF EXPERIENCE,
HAS, BY HIS INBORN ABILITY AND CLOSE STUDY OF
MEN, PLACED HIMSELF AMONG THE
LEADERS OF HIS PROFESSION:

TO JOHN J. HAGERTY
CONTRACTOR, OF NEW YORK CITY

382944

PREFACE

Andrew Carnegie is credited with saying that if he had to lose his plants or his organization, he would prefer to lose the former; for they could be replaced more quickly than his organization.

This is especially true of contracting. The building of an organization for this work means years of effort. Contractors just starting in the business quickly realize this; the older men in the field know that hundred per cent efficiency in any contracting organization is seldom reached.

The principles of modern management should leave nothing for chance to decide. Therefore, the successful contractor of today must break away from old inefficient methods and practise modern ways. To do this calls for real leadership.

In mechanical lines much has been done to try out this new leadership—to adopt scientific management and establish new standards for a greater efficiency in manufacturing.

It has been thought that these principles, so successfully applied in the manufacturing field, are not applicable to engineering and architectural construction. This idea, however, has been proven erroneous by the successful work of those pioneers in the contracting field.

The author's experience as a construction economist covering the past decade has taught him that scientific management is applicable to construction—he has applied and is applying the principles of such management with a fair degree of success.

This treatise is the result of the author's experience. It is offered to the profession with the hope that engineers and contractors can build up and strengthen their organizations for greater efficiency, making possible the earning of larger profits.

DANIEL J. HAUER.

April, 1918.

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MODERN MANAGEMENT APPLIED TO CONSTRUCTION

CHAPTER I

WHAT IS SCIENTIFIC MANAGEMENT?

Scientific Management? What is it? What does it Mean?

It is an attempt to gain greater efficiency from men and machines and is expressed by one authority as requiring high ideals, common sense, competent counsel, discipline, a square deal, reliability, planning, scheduling of operations, standardizing conditions and operations, and a system of awards, in order to reach the highest point.

Another writer places the following as essentials to scientific management: records of details, standardized conditions, standardized quality to find out what is to be done and how to do it, written instructions as to the standard method of reaching the required time or cost, and constant comparison of actual performance with the standards to see that the actual reaches the standard and continues to do so.

A third writer states that "scientific management prescribes the destruction of tradition. Scientific management calls for the rapid alternation of viewpoints from perspective to close scrutiny, from idealism to practicality, from preparation to execution. Men are wont to deprecate the line of conduct known as cut-and-try; but scientific management is exactly that course. It is the cutting of one's material according to a plan, and the tentative assembling

of the pieces. It is the disruption of vogued practice and the reconstruction of methods.

"One may, if he chooses, use the results of another's experimentation as a basis for his own cutting and trying; but unless he goes further, and applies the cut-and-try expedient to his new-found knowledge, he becomes, not a scientific manager, but merely an imitator. A man succeeds in the process directly in proportion to his understanding of his problem. There are all sorts of cutters and tryers, varying from men whose intuitions have all the earmarks of inspiration, down to those who cut their eye teeth in trying to learn scientific management out of a book. Scientific management involves much more than the formulation of standards. It comprehends the repudiation of standards. It demands the setting aside of preconceived notions and fixed ideas regarding business. It exacts the ever-readiness to abandon even the results of its own activity."

These are the broad general principles applicable to every line of business. For construction work the application is given by one authority in the following words:

"The aim of scientific management is to find the best and cheapest way to accomplish a piece of work and provide means for doing it in this fashion."

Scientific management or efficiency engineering is a broad subject. It includes the culling out of obsolete business ideas, the substitution of contract work for day labor, the paying of bonuses, the discarding of unprofitable parts of a business, the elimination of waste of both material and labor, the selection of plant and machines, the arrangement of plant and men, the operation of machines, the handling of tools and a hundred other details.

The work of the past has been mostly in the mechanical branch of engineering or commercial manufacturing. The work of the future will be in the *field* and under conditions that are seemingly against the efficiency engineer. This includes the engineering-contracting field—the work of rearing engineering structures—where the same man does not perform the same work twice; where the operations are

conducted at widely scattered places; where the workmen are incompetent and the plant is inadequate, the designing department poor or nil, and possibly the bank account has been exhausted.

Scientific Management a Necessity

Scientific management is not a fad; it is a necessity. It has been a great success in manufacturing and in the trades for selling. It is now being applied successfully to construction.

We are interested only in the work that has been done in other lines so far as we can learn lessons from them that can be applied to the contracting field. Those contractors who are among the first to apply scientific management to their work will reap the greatest rewards. Not only by reducing the cost of their work will they increase their profits, but by adding to the compensation of their employes, they will build up such a satisfied set of workmen that their organizations will be able to handle more jobs and do them at a smaller cost. This will enable them to underbid competitors and make their position in the contracting field stronger.

Those experts who are introducing scientific management into the construction field are known by several titles—efficiency engineers, construction economists and construction service experts. Their objects are all the same—greater efficiency. Men's methods may differ somewhat, but if each is the expert that he claims to be the results will be very much the same.

The question, "Can this kind of management be applied to construction?" is asked. The answer is that it has been and is being applied with wonderful success, in spite of the hue and cry of contractors themselves, the views of some engineering papers to the contrary, and the lack of confidence of many business men that contracting is susceptible of being benefited by scientific management.

One journal says: "Efficiency engineering is being made a nuisance in some parts of the country. The fact seems to

be that under certain conditions it is undoubtedly possible for a skillful efficiency engineer to suggest methods of conducting manual operations which will save money. These conditions are (*a*) the continuous repetition of the same acts, (*b*) the doing of these acts by numerous people, and (*c*) the grouping together of the people doing the same kind of work. . . . Where, however, the same work is rarely repeated, and, if it is, the same man does not perform it twice, and the operations are conducted at widely scattered places, efficiency engineering ceases to have any peculiar advantage and becomes merely a selection of men and machinery.

"Attention is called to these limiting conditions because the good work which efficiency engineering can accomplish in its legitimate field when conducted properly is likely to be made ridiculous in the opinion of many people unacquainted with it through the erroneous assumption that it is put forward as a sure cure for every business ill. Unfortunately, experienced efficiency specialists are in great demand. Therefore, unless the conditions are particularly favorable for their work, the manager will find it best to go into the subject by himself with the help of the many excellent books on it."

Comment on the foregoing editorial is hardly necessary. The writer of it condemns efficiency engineering for the very uses where it is most needed. Scientific management is not limited to manual labor, but applies to the entire subject as previously outlined, and especially to the selection of men and machines.

Books and Experts

As stated by one authority, the man depending upon books alone to learn and apply scientific management "becomes merely an imitator and has all of the earmarks of trying to learn it out of a book."

Books on any subject are not to be cried down. They are excellent guides and help to teach new doctrines.

But it takes more than a book on banking to make a successful banker, and it takes more than a book or two on scientific management to make a successful manager or even to allow him to succeed in changing his methods of running his work.

To obtain the best results, he must use the services of experts and such books as are suited to his particular line of work. These will be an aid in following the work of the expert and will allow the manager to understand the principle involved. It might seem that a man should be able to apply such management to his own work without the aid of outside help. To some extent he can do so, but it is seldom possible to obtain as efficient results as with the aid of an expert.

The reasons for this are numerous. The manager or contractor is generally so busy keeping the work going and attending to the many details that, even if he sees the need of improvements, he seldom has the time or opportunity to change methods or try new ideas. To turn these things over to an inexperienced man to work out may mean a greater expense in conducting experiments than the man may ever be able to save in eliminating wastes.

Employ a man with some experience in this line and place him within the organization and every one, from the general manager down, will be against him or else he will fall in with those in charge and help to keep in vogue the old methods. Such a man, working under an outside expert, will obtain results, but by himself, he will hardly effect enough saving to pay his salary.

With the outside expert it is different. He must make good. Hired by the month or season he must effect such savings that his own fee or wages will be insignificant as compared to them. If he does not do this, his employment will cease. He is not a part of the organization; he is outside of it and serves only the contractor. He is not bound down by the traditions of the organization. He neither serves his own interests nor those of the one employing him by trying to please the general manager or

others in the employ of the contractor. He can change old methods, destroy old traditions and tone up an organization as not even the employer can do, for he is without sentiment, looks only for efficient results.

Two Methods of Applying Scientific Management

In applying scientific management to construction work there are two general methods. One is to apply the idea to details; the second to apply it to the job itself. Each will show a saving, but the two together will effect the greatest economies.

For instance, much study and time may be given to some detail when the general methods are wrong. Systematizing of shoveling by hand may effect a great improvement on a job where hand work should not be used, but where machinery could be employed to greater advantage. Likewise, much money may be spent in reducing the cost of handling concrete with buggies instead of barrows when it would be possible to install a concrete mixer that discharges the concrete into place. Again, time and money may be spent in developing certain methods of doing work and installing machinery when, if the work had been properly planned, entirely different methods would have been used, causing the job to be conducted in a much more efficient manner.

Hence, in all construction work the first thing to do is to plan the job from start to finish. Jobs can be and are being run to make a profit without such planning or by only partial planning, allowing general methods and details to be decided upon from day to day. But the *greatest possible* profit can be made only by previous planning and by arranging a schedule of work.

No one must assume that in planning work in advance the superintendent is eliminated, for he is not; his functions are merely changed somewhat. It takes a higher type of manager to plan a job in detail from start to finish, arranging schedules, forces and machines, than to do work as it is now done. It is necessary to study carefully the

ground, work, drawings, specifications and details, the listing of quantities and other things.

The results obtained by careful planning will excel those of deciding each night upon the plans for the next day. The latter arrangement means haphazard management. Begin a job properly and it is much easier to take it through to completion, and to start off the second and third jobs.

Applying scientific management to construction work as a whole and not to the details only, means that the work must first be planned and routed. This necessitates the destruction of old traditions, and makes the new management revolutionary, which causes many contractors to hesitate to adopt it. The contractor thinks the old ways that he has used for years must be the best, and that an outsider cannot come to him and tell him more about running his work than he himself knows.

For this reason many economists must work to a disadvantage. They must take up the details first and improve upon them before turning to the great work of changing the entire system. The economist must, in some cases, fail because of these very conditions. Given a free hand and an opportunity to commence properly, the gain to the contractor would be quicker and greater.

"My Work is Different"

This is an expression that nearly every contractor uses at times. He is asked why he is not using certain kinds of machines. His reply is that they are not suited to his work. When told that such machines are being used on similar jobs his answer is, "But my work is different."

Upon one occasion the author visited a Canadian city where two large jobs were being carried on, one on each side of the harbor. So far as the foundation work was concerned they were identical, yet one was being done almost entirely by hand methods while on the other improved machinery was being used. The general manager of the job using the hand methods was asked why he did not use

the same kind of machinery as was being employed on the other work. His reply was, "My work is different." Further questioning disclosed the fact that he had not even visited the other job. His work was not different and the same kind of machinery could have been used, much to the benefit of all concerned.

The same answer has been given in many cases to queries regarding the use of certain methods or the adoption of new ideas about management. It is a fact that most men believe that *their* work is different from that of other contractors. The merchant and manufacturer think the same of their business.

Naturally every construction job differs to a certain extent, from others. In many ways, however, they are similar. It is by picking out these similar features and by applying new facts and business methods copied from others that many benefits can be gleaned. The broad-minded man, instead of resting on the assertion that his work is different, will attempt to find out in what respects his work *resembles* that of other contractors, so that he can profit by their experiences as well as his own.

CHAPTER II

OLD VERSUS NEW MANAGEMENT

On construction, once a job is secured, the first essential of modern management is the planning of the work. The lack of this planning is seen on every hand among contractors—on jobs large and small. In hundreds of cases it means the loss of all profits. Unforeseen conditions are prevented and the job is carried along on schedule by the most economical methods by planning the work ahead.

On one job two steam shovels were excavating a large pit in a hillside. Rock, encountered unexpectedly, had to be blasted. The overburden, some 15 to 25 feet in depth, had to be kept separate from the rock, and stripping was necessary. For this reason the steam shovels and much of the other work, were stopped while men with carts and scrapers were removing 30,000 to 40,000 cubic yards of earth. Here were two wastes. The first and most noticeable was the stopping of the work; the second was the expensive methods used to excavate the overburden before the work could be resumed.

If the job had been planned instead of deciding various questions from day to day this rock would have been located and the quantity of the overburden calculated months in advance. Instead of delays and expensive methods, this work would have been done in advance by suitable plant and at the minimum cost. This job was a large undertaking involving the expenditure of millions of dollars and was being done by an experienced construction company yet there was a very evident lack of planning and efficient management.

On another job the concrete mixer was worked only a part of the time. The reason for this was that it was not thought possible to keep the forms ahead of the concrete placing. This showed a woeful lack of planning and management, for on most jobs the forms can be placed so that the mixer works almost continuously.

Running a Job From Day to Day

A contractor and his general manager met as usual one night after their evening meal to talk over the day's work and to plan for the next day. The work in question was a large railroad contract with a few sub-contractors on it and several of the contractor's own camps.

"We did a good day's work today," announced the general manager. "All the forces were full, and everything ran smoothly at Camps One and Two, excepting that at Two I found them nearly out of coal. I doubled back on my horse to Camp One and had several wagon loads of coal carried to Two. Then I had to go to the railroad station to change over the teams to hauling to Camp Two, so they would have plenty of coal tomorrow. This prevented me from going to Camp Three, so I can't say how they got along."

"Very well," said the contractor, "suppose we have Jim, the bookkeeper, call up No. 3 and find out how they got along."

"Hey! Jim!" called the general manager, "phone No. 3 and find out what they did there today; I'll talk to the 'super' myself."

He found that at this camp the work had gone along well, except that at five o'clock the concrete gang had run out of crushed stone and had been switched to other work for an hour to keep them employed. Only a few loads of stone had been received by night—not enough for the gang to start on in the morning. This stone was being bought at a crusher several miles across country and was being hauled by the contractor's own teams.

With the information thus given, the contractor and the general manager began to plan the work for the three camps, each employing about one hundred men, for the next day.

At the start the question arose as to just how much each camp had done of the various classes of work, and how many men and teams had been worked in each gang.

"I can't tell that," said the general manager, "until I get my reports from the various camps in the morning."

"We ought to arrange this differently," replied the contractor. "We need this information each evening when we make our plans for the next day. When we get time we must arrange so we will have this information the same day. Now it will be necessary to find out how large the concrete gang is at No. 3, and how much coal they have at No. 2. These are the important matters for tomorrow morning."

Accordingly some more telephoning was done, after which plans were again discussed.

It was decided to have the general manager leave early in the morning for Camp Three. As Camp Two had enough coal for the day the manager was to take several teams from this camp to the crusher plant. At Camp Three several teams were to be taken out of a scraper cut and put into wagons. These extra teams, with all the regular hauling teams from Camp Three were to haul crushed stone so that by noon there would be a supply on hand to start the concrete gang.

Meanwhile two men were to overhaul the mixer, and the rest of the concrete gang was to be employed in repairing the steam shovel track on the dump at Camp Three.

The contractor was to go to the railroad station with teams from Camp One and have them haul coal to Number Two so as to get an ample supply on hand to set the teams at each camp at their regular hauling for the next day.

Thus the work was planned, the other forces being kept at their regular work. The next day the general manager and the contractor rode away before six o'clock to carry out their plans. Both men possessed an unusually large

amount of energy. They hurried their teams and soon a great deal of the hauling was finished.

New Difficulties

At noon the contractor, returning to his office, found a message from a sub-contractor, saying that some cast iron pipe had to be hauled and placed that afternoon or he would be compelled to stop two scraper gangs by morning. The contractor had to get busy at once. He knocked off two scraper teams at Camp One, hitched them to pipe wagons and sent a foreman and several men in another wagon, with tools and cement, to place the pipe.

He rode along himself to see that the men started properly, and before his return found that everything was moving well except that a dinky serving a steam shovel had been derailed and the car replacers at that camp had been borrowed for another camp a few days before and not returned. The superintendent was attempting to replace the dinkey with track jacks.

Another scraper team was taken from the gang, hitched into a wagon and dispatched for the replacers. By the time they arrived the superintendent had put the dinkey on the track and everything was going smoothly.

Meanwhile the general manager had received word that the form makers at Camp Two, working on a large concrete arch culvert, were nearly out of certain sizes lumber that they were using that day. This surprised him. He had ordered that lumber himself, had figured the amount needed, and had received the bill for it several days before, properly checked by the timekeeper at that camp. He rode at a gallop to the concrete culvert.

Arriving there he found that the lumber had been received as reported, but that the carpenter foreman had not been furnished with a drawing showing how the timber was to be cut and the forms designed. As no drawing had been made, the carpenter had followed his own ideas and instead of making each stick of timber give two pieces,

the framed length was made longer and there had been considerable waste. This caused the shortage of material.

The damage was done, and the cheapest way out of it was to send five miles to the saw mill to obtain more timber. At this camp there was no scraper force to be drawn on, so the general manager rode out and hired two teams from farmers and sent them off with an order to the mill for the necessary timber. Thus, by quick action, a force of high-priced men would be kept at work the next day.

A Foreman Saves Money

On the ride back to his office along the line of the work the general manager found the various forces making good progress. One foreman, however, stopped him to point out that he had three wagons in a run which he was loading by hand. The foreman felt certain that if he were furnished with four wagons and two teams of horses, in place of the three wagons with horses for each, he could increase the output of his crew and yet reduce the cost. This could be done by having his drivers leave empty wagons in the cut, while they took the loaded ones to the dump, changing the horses from one wagon to the other on each trip.

This appealed to the general manager, as at that time he was short of horses for hauling, and an extra team and driver would be a decided help. Accordingly he talked the details over with the foreman and told him he would arrange with the superintendent to make this change in the morning.

That such a saving could be effected had not occurred to the busy general manager. These things were part of his work, but his time and thought were taken up with the larger and broader problems of keeping the entire job going.

Again, at night, the contractor and general manager met to discuss results and plan for the next day. The job, they thought, was moving on well and some profit was being made. Both being forcible, alert men, the job was being carried on from day to day, by close attention and by thrusting themselves into every emergency—keeping

machines, men and teams at work, and changing them from place to place as necessity demanded. The contractor and general manager together directed the work.

How Money Was Wasted

This short story is told because its parallel has occurred and is occurring daily on hundreds of jobs throughout the country and because it offers a comparison with modern methods of management.

On this job the general methods of doing the work and the kind and probable amount of plant had been decided upon in advance. Each day's work, however, and the various kinds of work to be done were planned from day to day and from week to week. Materials were ordered in advance as much as possible, but there were no schedules of time for this or for any details of the work, as would be used in managing a job on scientific principles.

First, the cost records, lists of work done and materials received were not sent to the contractor's office until the day after they were made out. Nor were the records analyzed and compared with the amounts of work done on different days and with the original estimate.

This fact placed the contractor and his general manager at a disadvantage in directing the work and keeping down the costs. These nightly conferences are good features, but if the work were planned along more efficient lines they would not be absolutely necessary, nor would the daily records be so essential in directing the work from day to day, for all details would be considered and provided for weeks in advance.

The fact that the supply of coal ran short at one camp meant the extra cost of transferring teams and hauling coal from another camp. Running out of crushed stone meant another money loss. These things should not have happened with efficient management, as ample supplies should be on hand and a daily report made of the amount on hand and received.

Teams were switched from one camp to another. This meant extra distance to be traveled. In addition, teamsters seldom do their best work when they are changed around from one place to another.

The stopping of scraper teams at two camps and putting them at other work meant the breaking up of the regular scraper runs, adding to the cost of excavating, loading and dumping. Such things as this can be prevented.

For six hours a concrete gang was placed at other work. Their foreman—a concrete man—did not do good work on the track, as he knew little about it. He was dissatisfied; his men were quick to take the cue from him and did not overwork themselves in fixing the track. A smaller crew of regular track men would have done quicker and better work.

Few contractors seem to be able to keep their concrete gangs regularly at work mixing and placing concrete. This can and is being done under the proper system of management.

The fact that scraper teams had to be stopped to haul and place cast iron pipe for a subcontractor was another mistake of management. This work could have been sublet with the grading to the subcontractor, or it should have been planned ahead, showing the need of progress reports even on work sublet. Under the proper system of management, pipe should be hauled directly to the opening for which it is ordered and placed in advance of grading. Not only was there a loss in this case due to stopping teams, but a foreman and his crew were taken from their work and sent across country, riding when they should have been working.

On construction track locomotives will be derailed frequently. In the case cited the accident was made more expensive by not having the proper tools at hand. Every locomotive should be equipped with a set of car replacers, as there is then no reason for replacers to be borrowed from one camp for another. However, if such things are borrowed, a proper system of checking up tools will insure

their prompt return. Modern management takes care of this.

Modern Management Cares for Details

An expensive blunder was made in running short of form lumber. This could have been prevented, and a bill saved for hired teams and additional lumber, by having drawings made of all form work. Not only should such drawings be made, but also sketch cards should show how the various size sticks of timber should be cut and framed. The sketches should be so devised as to reduce the work to a minimum. Foremen and carpenters are found to waste lumber otherwise, and they will, in many cases, do more work in handling and framing timber than is necessary.

The fact that a foreman stopped the general manager to discuss with him how to increase his crew's output and at the same time save a team and driver was commendable. With modern management the knowledge of foremen and workmen is anticipated and used to make the work more efficient. Methods are devised to have the men offer suggestions and for the management to assimilate such information for the common good of the job.

Under modern management the contractor and the general manager, with a corps of assistants, plan the work, manage the schedules (both time and material) route the work, making drawings and instructions for all details, and devise reports. When this is done they no longer direct the work, for, in doing these things, they have already issued the directions. They become a part of the organization to carry out these directions, and it is as necessary for them to obey their own instructions and follow their plans as it is for the humblest apprentice on the job to do so. It takes as much ability, if not more, to do this than to direct work under old methods.

CHAPTER III

PRINCIPLES OF MODERN MANAGEMENT

Some contractors claim that their jobs are always planned in advance and that the work is done according to a well-thought-out plan. If asked to see their plan they finally state they have nothing on paper but have planned the job just the same. This means that the contractor and his superintendent and possibly his engineer, if he employs one, have talked the matter over before starting and have, from time to time, discussed their plans as the work progressed. Thus machinery has been ordered and placed at work, certain forces have been employed as they were needed and building materials have been ordered. Some plant has been on the job before it was needed and has been moved from place to place as desired. Men have been kept busy and the cost of the work has been noted on cost forms each day, but no one knows whether these costs are lower or higher than the estimates.

Some machines have not arrived when they were needed and hand methods have been used temporarily. Enough men have been employed on certain parts of the job while insufficient forces have been used on other parts, hence there have been delays that have caused one gang to wait upon another. Materials have been brought onto the job in such large quantities that they have been in the way and some of them have had to be rehandled unnecessarily. At other times delays have been caused by lack of material. These details show the dearth of proper planning of construction jobs.

Planning Construction Jobs

Planning consists of many things. First, it demands complete plans and drawings for the work in hand. Plans cannot be made for building a structure unless the details of the design have been prepared and from these the kinds and quantities of the work determined. There must be a very complete knowledge of the work. There must be a schedule showing the time of carrying on the job, so that machines can be installed when needed and supplies can be on hand so that no extra expense will be caused either in rehandling or in waiting. The various details must be mapped out and charts made of them. The items of work must be separated and figured out and the various lines of work routed so that the entire job will move as a unit.

Some contractors state that this is not possible, that no one can foresee all the possible conditions and that many things will occur to interfere with these plans. They say that only a theorist would advocate such a course. There can be little doubt that plans may fail and that, in some cases, changes may have to be made. These things now happen continually, but they will occur less often when all conditions and particulars are taken into consideration. Then, too, the few exceptions cannot be accepted as the rule.

Another objection made is that it is impossible to plan work weeks, months and even years in advance. The fallacy of this is shown in war—in the handling of armies.

The most able generals in the world have planned campaigns weeks and months in advance and their plans were carried to success, not simply by planning, but by following up their plans, making changes when necessary and giving attention to the many details.

If it is possible to plan the details of such a campaign in advance, it is certain that a contractor can plan his work in advance. In fact, a contractor can be likened to a general. Each has men and machines to handle and must arrange for a commissary and for all necessary supplies.

Men and machines are disabled or drop out and each must be replaced. The general plans his maneuvers from maps of the country and information furnished by his scouts and spies; the contractor plans his maneuvers from plans and specifications furnished by the engineer and from information obtained by himself or subordinates in going over the proposed work. This is preparedness—and it is such planning as this that brings success in a war also it is such planning by a contractor that means the greatest possible profit from a job.

The fact, too, that such planning is being done successfully is proof that it is practical and it goes without saying that work so planned is carried through to completion at a low cost.

Efficient planning is not easy. It is an undertaking that can be done by one man, but which is more successfully handled by a number of men, preferably by one man with a corps of assistants.

The Highest Test of Management

This planning is the highest test of management. It is not bound by precedents, it may be revolutionary, but it must consider only one thing, THE JOB—this word must be written in capital letters. It stands at all times for the structure that is to be built. It may be a dam, a railroad, a bridge, a building or any structure. The name of the structure can be substituted for THE JOB, but the latter stands for any kind of a construction contract.

This type of management of THE JOB is superior to all others. It takes an abler man to inaugurate and to follow it up. It may mean the doing away with the individual who inaugurated the system and management. The working together spirit that makes the success of the work dependent, not on any individual, but upon the whole working force.

It means obedience, from the manager down to the humblest workman—obedience to the plans made and to the

accompanying instructions. Yet the men are not mere machines, for they are given an incentive to think and to improve upon old standards. It is the perfection of a system, devised by an individual, yet one which, although it takes into consideration individualism, does not depend upon the individual, not even upon him who devised it. The ideal of management based upon scientific principles is to obtain the greatest efficiency.

Not only are the old standards of management considered but there must be included much that is new to the manager and much that has hitherto been left to the workman, many details that have previously been considerd beneath the notice of the manager. These include too long a list to be recorded here. The most important, however, is the routing of the work—the handling and transporting of the materials. This is a wonderfully broad and extensive subject and will be discussed in detail later.

Such work as the cutting up of lumber and the handling of it must be planned. Skilled workmen must not handle materials. It is their duty only to work upon them and place them. Every detail of manual labor of which artisans can be relieved should be done by unskilled laborer. By this means, in framing ties for a railroad bridge, a day's work for a carpenter was raised from 60 ties to 120, the saving thus effected being equal to a handsome profit. Nor is it left to a workman to decide how to cut up a piece of timber. Instructions should be issued to reduce the work to the minimum and to save lumber. Tools kept in repair and properly stored, save time in finding them and insure men against working with poor ones.

Small details and methods must be learned from the men so as to include all of these features in the plans. Nothing must be taken for granted. Inducements should be offered to the men to make known their knowledge of such things to the management, and likewise to improve upon their own methods.

Planning of jobs cannot be done to the best advantage unless those responsible have an intimate knowledge of

construction plant—information about all kinds of machines and the adaptability of each class of machine. Likewise, the contractor should have a knowledge of the relative value of each manufacturer's machines. This plant knowledge is one that many contractors and their managers lack. Exact information is difficult to obtain, except from personal experience, and it is not possible to experiment with every machine on the market. For these reasons services of experts are needed in planning jobs.

These points illustrate how intricate a problem it is to plan construction jobs well. But any planning of jobs, even if it is done indifferently, is a vast improvement over the hap-hazard method. A decided improvement will be made with each job and with many contractors following this type of management it will not be long before such data will be collected as to make the task much easier.

The work of planning a job can be divided into five general headings, each with a number of sub-headings. Each heading can be handled by a different man or set of men, all working under one man. Or, if desired, a few men can handle the entire work unless the job is a very large one. In this case several departments can be established, the heads of each consulting with one another. The engineering department will have to serve most of the others in making drawings and sketches. The work of some of these departments, for some classes of construction, will last throughout the life of the job.

For small jobs all of this work can be done by one man. The division of such work and the establishment of departments depend upon the size of the operation, but the general principles are the same for a three hundred dollar job as for a three million dollar undertaking. Each heading and sub-heading will be listed and considered separately.

1. Planning General Methods

Under this heading the contractor and his manager, after visiting the job, and after making a close study of the

plans of the owner and the quantities of work to be done, will consider the following:

(*a*) *General Plans.*—An outline will be made of the general plans and methods to be followed throughout the life of the job. This will be turned over to the engineer to be mapped out in detail and such copies made as will be needed.

(*b*) *Plant Selection.*—The various kinds of machines to be used will be decided upon and arrangements made to have them on the job when needed. This list will also be turned over to the engineer for use in making plant layouts.

(*c*) *Time Schedule.*—From plans, quantities and other information a schedule of time for doing each class of work will be mapped out, so that the work will be done within the contract time. This schedule is turned over to the routing department.

(*d*) *Estimates of Cost.*—When the job is bid upon estimates of cost are made to fix the bidding prices. These are gone over and revised to be used as a standard for comparison of cost records. Such estimates are retained in the office to be used by the cost department or clerk.

2. Designing and Engineering

Under this heading comes the direct work of the engineer in charge for the contractor or his engineering department. Its work is most important and will extend to the other headings or departments.

(*a*) *Making Charts and Plans.*—All the general charts and plans will be made by the engineering department and general instructions and information furnished in writing from such charts and plans.

(*b*) *Designing Plant Layouts.*—Surveys will be made of all work and sites for plants and storage yards, and from such surveys layouts will be planned for installing plants and serving them, as well as storing and handling materials.

(*c*) *Designing Structures and Rigging.*—This is done by the engineer in the office and is not left to the discretion of the foreman or workman in the field. The plans so made are standards, many of which can be used on different jobs, thus saving extra work and allowing the men to become accustomed to standard designs.

(*d*) *Quantities of Work and Material Lists.*—These are made from data and plans furnished by the owner and are absolutely necessary if the work is to be planned intelligently. All the work of this department is used by the next, the routing department.

3. Routing Work

Much of this must be done in advance of starting the job, but it continues throughout the contract.

(*a*) *Sequence of Work.*—The first task in routing work is to decide upon the sequence of the work, especially upon how one detail follows another, as well as how the various classes of construction are carried along to make a complete job.

(*b*) *Routing the Handling of Materials.*—In this the arrival of the materials upon the job is arranged and also their storage. The handling of the various materials is so arranged as to reduce this work to the minimum. This eliminates many wastes.

(*c*) *Distribution of Work.*—Under this sub-head the work is so routed and distributed as to make the cheaper men do as much as possible and the higher-priced men no more than necessary. It is also so planned that machines and teams are served so that they are not idle, thus keeping the costs at a minimum.

(*d*) *Number and Size of Gang.*—From the distributions, the plant layouts and the time schedule, the number and size of gangs needed and the make-up of the various gangs are decided upon. These are estimated carefully at the start so as to complete the job on contract time.

Conditions may arise, however, that will cause changes to be made.

4. Instructions For Workmen

The management proper assumes the direction of the workmen instead of allowing the men to follow their own methods and inclinations.

(*a*) *Instructions for Mechanics.*—All instructions for mechanics and artisans are furnished in writing, accompanied by sketches, whenever necessary. Such instructions should be issued in series and many of the cards can be copied for use again. This is work that must be done daily and it is possible to make these instruction cards part of the cost keeping system.

(*b*) *Instructions for Common Laborers.*—These can seldom be written but must be given to the men orally by the superintendent and foreman and at times must be practically demonstrated. Men must be taught how to work and how to follow the best methods and, in some cases, how to handle their bodies and tools. The instructions for all of this can be issued to foremen in writing and illustrated with diagrams and sketches.

5. Basis For Rewarding Workmen

To induce men to obey and put forth their best efforts to reduce the contractor's cost, an incentive must be offered to the men that will guarantee their wages and something extra if their work has merited it. This becomes an important department and means that the office is dealing directly with the men. The work of this department is divided under two headings: A. Tasks; B. Costs.

A. *Tasks.*—Tasks must be set that will allow the poorest workmen to earn a living wage and certain bonuses fixed that will give additional compensation for increased work.

(*a*) *Deciding Upon Wages.*—For all of this there must be a basis for wages of all men, fair to them and also to the

employer. By instructions and assistance each man must be made, if possible, an earner of a daily bonus. Thus he is rewarded liberally and the contractor is netted an additional profit.

(*b*) *Further Incentive to Workmen.*—To prevent making a man an unthinking machine, further incentive must be offered in the way of a bonus to have a workman impart his knowledge to the management and to keep the workmen thinking and devising new methods for increasing the output of machines and men. This may be in the work he is doing himself or that being performed by others.

B. *Costs.*—Cost records will show the results that are being obtained from the men and the collection of costs will assist in fixing a basis for rewarding workmen.

CHAPTER IV

FINANCES AND EFFICIENCY

Before discussing in detail the various features of modern management outlined in the previous chapter it is necessary to take into consideration some general features of contracting and some of the details of modern studies made in connection with modern management. This will make the entire subject easier to grasp, as the treatment will be more comprehensive.

Modern Management and Finances

The financial side of modern management as applied to construction work is not different from that in any other line, but it presents a peculiar proposition. A contractor making money feels that he is carrying on his work by the proper methods and that no one can improve on his scheme. He will also reason with himself that any outsider is an unnecessary expense and may tend to break up his organization.

On the other hand, a contractor who is losing money, although he is trying every expedient to make changes in his work and turn his jobs into profitable ones, will feel that he has not the money to pay for the services of an expert economist, who may be able, by improved methods and by eliminating wastes of labor and materials, to make the jobs net a nice profit. Thus each man, for different reasons, hesitates to engage an expert and both because of money consideration.

An efficiency expert, if he is competent, is allowed to carry on his work unhindered and receives support from the contractor and his superintendent, will pay himself. He will effect such a saving on the work as to pay his own fee or

salary and net the contractor some additional profit. The economist is not looking for a week's work, but for an engagement extending over some months, and he must make good in order to have his employment continued. Thus he solves the question of paying himself.

As he enters into this financial question, so does he enter into other phases of the financial side of contracting. Modern management begins with estimating on new jobs. The proper system will prevent mistakes, and will place estimating on such a basis as to eliminate from contracting some of the elements of chance. It will also give a reliable standard by which to judge the efficiency of the jobs from day to day and from week to week. Then, too, a profit cannot be made on a job if the bidding estimate is too low. This is evident, and modern management is one means of preventing such a financial disaster.

Capital Must Be Considered

In carrying on work the capital in hand must be considered. In other words, the job must be planned to suit the finances. It is not always possible to obtain new machines or those best suited for the work. There may not be money at hand with which to purchase them. It is, therefore, part of the business of the management to plan the work so as to earn the money. This is done in two ways: by reducing the cost of some of the work to increase the profit, and by planning the sequence of the work so as to finish certain parts by a given time, in order to earn enough money to pay for such machines as may have to be purchased.

Modern management is the opposite of that principle that attempts, by expensive speeding-up methods, to make a losing job a profitable one. Many contractors have attempted this to their sorrow. Before speeding up is brought into play there must first be a cleaning up—the doing away with all waste and the adoption of the most improved methods. For it can be seen that if wastes are

going on they are only increased by speeding up the work. A steam shovel operated incorrectly is not being improved upon by working it both day and night. It is only hastening the contractor into bankruptcy.

It becomes evident that modern management embraces the financial side of contracting as well as the operating end. This is not only true in starting operations but is also the case from month to month. If any class of work or any contract is not netting a profit, then it is necessary to go into such financial details as to find out why these things are so, and, the cause once found, it becomes possible to apply the remedy.

Some classes of work that cannot be done by the general contractor at a profit may be let as a sub-contract on a profitable basis. This may be due to the contractor's lack of machinery, or skilled workmen, or to the fact that overhead charges are eating up the profits. The sub-contractor may not suffer from such causes and at a smaller price is able to make money.

An Exhausted Bank Account

A contractor with an exhausted bank account needs the services of an economist more than does the man with ample capital. He really has nothing to lose and much to gain. Modern management, if properly applied, especially if the contractor has the "efficiency will"—belief in this modern system of management—will go far towards changing a bank account. It will not create a business without capital, but it will take a going contracting business with a depleted bank account and within a few years create a surplus of cash. These statements are not made on hearsay or based upon theory, but upon actual practice in the contracting field.

It is evident that if such things can be done with limited credit and funds, then much greater results can be obtained when ample capital is already provided. Then it is possible

to plan work on an even better basis, to obtain results that in the end will net even greater profits.

Finances handled in contracting with these ends in view not only means a profit, but means even more—the greatest possible profit to be made from each job.

For these reasons, if a contractor decides to engage an efficiency expert, he must make up his mind that he is to hide nothing from the expert. His financial standing must be made known. His standing for credit with merchants and manufacturers, and also his resources as to cash and plant, must be laid before the expert. These things done, the expert starts his studies in efficiency on a known basis and is able to give the best that is in him, amply repaying the contractor for his confidence.

Efficiency Must Be Applied

Efficiency can be taught; it can be written about and studied; it can be preached; it can be illustrated by many examples, but no one can profit by it unless it is applied. The degree of efficiency reached matters but little, whether it is 10 per cent or 100 per cent, if the party most interested simply reads or listens and then goes on following his old methods. Food must be eaten to furnish nourishment to the body; efficiency must be applied to produce its benefits.

Every intelligent man talks of efficiency, believes in efficiency, and even asserts that he himself is efficient. Likewise, if he is a contractor, he knows that his organization is not 100 per cent efficient, yet not one contractor out of a hundred will consider using an efficiency engineer or an economist.

Most contractors claim that they are doing some work of this kind themselves. Some state that they have employed some engineers who are in charge of their cost keeping and efficiency work. These men are a help. They learn much of the contractor's methods and are able to make improvements; but in spite of the fact that they earn more for their

employers than they are paid, this system of applying efficiency or modern management never brings an organization anywhere near 100 per cent efficiency.

Were the Old Days The Best?

There are a number of reasons for this. Some engineers, being kept closely to their work, become accustomed to the very methods they are supposed to change, if it is necessary to do so. It is an inborn characteristic of man that he thinks that those things with which he is familiar and becomes accustomed to, are the best. This has been the song of the world since the early history of man. Nestor, the ancient Greek hero, told how the men of his early days were the best. Herodotus told how the old times and customs were better than those of his day. The ancient bards told the same story. Yet the world has made wonderful strides in each century and will continue to do so. But the man who attempts to revolutionize customs or anything else, is ahead of his times. The world changes, but it changes slowly.

Efficiency Within The Organization

Another disadvantage under which the efficiency engineer within an organization labors is that he does not visit other jobs. Thus he does not see other methods being tried. He does not see new machines, or different types of machines and appliances. He is also cut off from seeing ingenious devices for saving time and money, and those hundred and one things that mean better management and more efficient work.

He can get the full benefit only by actually seeing and having experience with these things. It is possible to read of many things in trade journals and engineering papers, but unfortunately the writers for such papers are limited as to space and it is seldom possible to go into such detail as to make possible the application of all that is set forth in

these journals. To a great extent this is true of books. A writer can set forth the general principles and many details, but he cannot put down that personal experience and judgment that counts for success.

One factor that counts against the application of efficiency within the organization is the personal feeling that exists in every organization. The engineer makes friends. He will probably favor his friends and accept their opinions instead of obtaining facts from actual observation and records made by himself or assistants. Then, too, he will make enemies. And a general manager or superintendent will resent many things that the efficiency engineer may have to do and will prevent the best results from being attained. In many cases changes of methods and machines will not be made when they should, because several high officials will get the ear of the contractor and show that the efficiency engineer is a theorist, while they are practical men and that these charges mean only increased costs. These things mean discord which is a great disorganizer and reduces the efficiency of the forces.

Lack of plant knowledge and prejudice are likely to rule the selection of machines. Every man has his preference for certain machines. This preference may be based either upon an extensive experience with different types and makes of machines, or upon a limited experience with only one or two machines (in too many cases the latter). Thus prejudice instead of knowledge may govern. It is seldom possible within a single organization, even if it is a large one, to gain that intimate knowledge of plant that is obtained by experience with many contractors in different sections of the country.

Another feature of efficiency work done by a regular member of the organization is that the work is only productive of money results indirectly. Hence the efficiency engineer is considered as one having plenty of spare time, and is soon loaded up with extra work that will bring direct results. Thus it is possible to sidetrack entirely the efficiency end of the business.

Too many contractors think that to introduce modern management means first to break up his organization and reduce its efficiency before more beneficial results are obtained. Some economists may work in this manner, but few who are competent do so.

Many contractors have good intentions of introducing better management and better methods into their work, but it has been stated repeatedly that the road to the lower regions is paved with the good intentions of well meaning men.

Efficiency From Without The Organization

The best results are in most cases, obtained by employing a man from outside the organization as an expert to introduce modern management and work for perfect efficiency. For a small organization this one man may be enough. For larger organizations this expert acts as a consultant, while one or more men working under his directions are placed in the organization.

The outside expert is compelled to make good. He is looking for employment and not for new clients each day. Therefore his work must bring results quickly or else, as in the case of a doctor, a new one will be called in to succeed him. Then, too, the outside expert builds up his practice by being able to show satisfied clients.

He brings to an organization not only the best that is in him, but also the best from every organization in which he has worked, and likewise from all the jobs he visits. His experience is based upon personal touch. He has the advantage of both the articles in papers and books, some of which may be of his own writing.

Seeing many different types and makes of equipment and having made both time and motion studies of them, the expert has intimate knowledge of a greater variety of machines, and this knowledge is enhanced by his securing more clients.

The expert serves only the contractor. He has neither friends nor enemies in the organization, and thus stands aloof from all the employes, working, not to antagonize them, but rather to mould them into an organization that may be 100 per cent efficient.

Efficiency Will

These things being so, why then are contractors not employing experts to apply modern management to their construction jobs? The answer is a simple one and is furnished by one of the ablest economists in the country, B. A. Franklin, who states that these employers and captains of industry do not possess "efficiency will."

This term he has coined and defines as follows:

"Efficiency is, first of all, or needs first of all for successful operation, a certain state of mind. This state of mind involves first the belief that efficiency, beyond that already attained, is certainly possible, attainable, and vitally valuable; second, the understanding that efficiency, like any other result of value, is to be attained and maintained by study, records, organization and inspection demand maintenance expense; and thirdly, an active determination of the executive organization to co-operate enthusiastically and continually. This state of mind may be called efficiency will."

This efficiency will is absolutely necessary if modern management is to be applied and the greatest possible degree of efficiency attained. It is not enough for a man to state that he has it; he must show that he possesses it by engaging in the work of bettering his management.

Excuses count for naught, showing only that a man lacks confidence in himself. One contractor said, "I believe in efficiency and have been giving the subject lots of thought and have already bettered my work, but times are dull and I only have little work going on, so I have decided to defer action in this matter until I get more work."

Another said: "I have gone into this subject and it possesses merit, but I am too busy to tackle it now and

can't afford to run the chance of breaking up my organization."

A third stated: "I am convinced there is a whole lot in this efficiency business, but I am a small operator. It is better suited, in my opinion, to contractors doing a large business."

"Improved management and methods," a fourth contractor exclaimed, "is the crying need of every contractor. It is a broad field, but my work is different from most others. My organization, though a large one, has been built up slowly and we have adopted many new ideas, and could not afford to make changes at the present time."

"Scientific management," said another contractor, "is all right for the man who can afford to hire experts, but I am losing money and have not any to spare for such things. I want to use my money to pay my bills, and am pushing my work for all it is worth to do so. I will consider it when I get some money ahead and can afford such luxuries."

Many more remarks similar to these could be quoted. None of these men, in spite of their statements, had the efficiency will, for if they had they would have given the answers to their own statements.

When work is slack is the easiest time to change an organization and get men accustomed to new methods, for when more work is taken up the system has only to be extended.

On the other hand if a contractor is very busy his leaks are apt to be more numerous, and in the attempt to make greater speed new leaks are likely to occur. Better management may prevent these things. A busy man wants the greatest output for the least money and the expert can give him this.

The small operator needs efficiency as much as the contractor doing a larger business, for a money loss that would have but little effect upon the larger operator may use up the other man's small capital and put him out of business.

Every man believes his work is different from that of others in his line. It may be in some details, but the general principles are the same. An organization built up from a small one, even if it has been progressive in its ideas, is bound to have defects in it—many of long standing. The fact that an organization is old does not necessarily mean that it is a well balanced one nor that it cannot be improved.

The man who is in financial troubles needs the services of an expert more than one who is making money rapidly. He cannot expect to make money by forcing his men and machines, repeating, in an exaggerated form, the mistakes that have caused his money loss. Then, too, an expert economist or efficiency engineer is not a luxury, nor does he cost the contractor any money, no matter if the operations are small or large, if the organization is busy or lacks work, if the contractor is in financial straits, or is making money. The economist pays himself from the money he saves by stopping the wastes of labor and materials, by giving better methods of estimating, inaugurating the use of better machinery, and by bringing new ideas to the organization.

It is the desire to obtain these things and the ability to see that modern management will be the means to this end that gives a contractor the efficiency will.

Efficiency engineering is in its infancy. Hence it is in a state of development. But it is steadily being given more and more recognition as a profession, and as a branch of engineering science. There may be some men entering the profession without the necessary experience and standards, and even without the natural ability or temperament, but they are no more likely to do harm than any other unworthy member of other professions.

The business man's view must be considered in these matters. He feels that no one is as expert in his own business as himself. He has created his business; he has nourished it and built it up, and no one can be as successful with his organization as he is himself. His own individuality has counted in this and is the important factor.

Again to quote Mr. Franklin:

"The ability of individuals, it is true, has made for greater successes, but only as they have guided and animated or energized the general plan of operation.

"Every business, then, has at least two general divisions. One division deals with the particular article or articles of manufacture, the machinery of its processes, its grade and quality and those elements which pertain to its peculiarities. But another division deals with methods and practices which in principle are necessary and common to all businesses, *i. e.*, organization, planning, marketing, storekeeping, costs, waste saving, incentives to labor, etc.

"Out of this common necessity there has logically grown the fact that there have been different developments along the line of this second division, and similar developments of varying degrees. Here and there analysis and experiment are still developing fundamental theories and improvements in practice of economic value in some business, which are of value to all. The busy main executive, tied down with daily detail of his own business and struggling with the difficulties of his own peculiar production and problem, cannot know of these developments; or knowing, generally, cannot put them into detailed practice."

These are the duties that develop upon the expert employed for this particular work. To employ such an expert on the part of the contractor there must be a proper state of mind, or *efficiency will.*

CHAPTER V

FUNDAMENTALS IN CHOOSING TYPE AND AMOUNT OF PLANT

One principle or rule of modern management, as applied to construction work, is that of selecting and using machinery for hand methods, and the use of modern appliances instead of obsolete types, keeping always in mind the selection of those types of machines best suited to the particular class of construction and having the greatest range of work.

This principle is being recognized by many of the leading contractors and engineers of the United States and Canada, yet in some details it is not being followed. It is also necessary to mention certain limitations to the use of machines. In other words, it is not only possible for a contractor to have too little plant, using hand methods when they should not be used, but, on the other hand, it is possible to use too much plant on a job and to own too many machines.

In the past few contractors have given time and thought to this phase of their business. Those possessing little capital and indifferent credit have attempted to do much work by hand. Others having the means to buy plant have used it for the greater part of their work, yet have continued hand methods for odd jobs, believing this to be cheaper. Some contractors have reasoned that if one machine of a certain type saved money, two would be better than one, and have bought more plant.

Thus it becomes necessary to discuss these features so that the mistakes made in the past can be avoided.

The Economic Plant

This is a subject that is of interest, not only to contractors and engineers, but also to manufacturers. With any given sum of money to be expended upon construction work within a limited area, or, for that matter, on a continent, for a year, what per cent of this money will be spent for plant? If data were at hand to answer this question a distinct step forward could be made by contractors and manufacturers. The contractor could limit his purchases and plan his work on a more economical basis and thus keep down certain overhead charges, while the manufacturer would be able to tell if he were doing all the business that he should be doing. With this knowledge, business could be handled on a better basis.

As it is now, men must study their business continually, arranging for a peak load in manufacturing and construction during prosperous times and retrenching during business depression. It is not possible to estimate the exact amount of plant needed by a contractor doing a given volume of business. Each job must be treated separately and a decision made for every new undertaking.

Lack of Plant

There is a lack of modern plant on many jobs. This causes a great loss of money. Hand methods or obsolete machines and makeshift devices are used. Modern methods demand that sufficient plant be installed upon all construction jobs. Not only is the unit cost of the work thus decreased, but the completion of the job is so hastened that the overhead charges and the general expense are likewise reduced. A common excuse for a lack of plant is that of insufficient capital, which has been dealt with at some length in The Economics of Contracting, Vol. II, to which the reader is referred. Chapter IV of this book will likewise be of assistance in dealing with this subject.

Using Makeshift Machinery

It is quite surprising, in visiting construction jobs, to see how frequently makeshift expedients are being used at an extra cost, instead of plant that can be purchased for the same purposes at a small cost and operated economically. There is hardly a large construction job where one or two such pieces of apparatus are not used at a greater cost than that of operating well made appliances.

There are two reasons for this. First, some piece of plant or apparatus may be on hand that is not meant for the work, yet it is believed that it can be used economically, especially as the amount of work to be done with it is small. Second, those in charge may not know of various appliances that can be purchased for the work in question, so rig up something of their own.

There are two causes for this. Although a contractor may keep cost records of his work, such records are seldom analyzed nor compared with the cost when different methods are used to do the same work. A comparison of the daily costs with a standard of costs or with the estimated costs used in bidding upon the job is seldom made. Thus quick conclusions may be made from impressions that seldom prove correct. Extra costs are lost sight of later as they are not analyzed, and the various troubles and delays caused by such makeshifts are forgotten after the job is finished, so that the same mistake is repeated on other jobs.

The second cause is simply a lack of plant knowledge.

Hand Methods

Hand methods in construction cannot be eliminated entirely but for most classes of work they can be greatly reduced by the intelligent use of machinery. The first essential is for the contractor to know what machine he can obtain.

In many cases, in spite of the fact that manufacturers are spending thousands of dollars in advertising their prod-

ucts, as well as large sums of money in furnishing expert advice to contractors and engineers through their service engineers and salesmen—in spite of the fact that technical journals are publishing hundreds of articles annually on the use of all types and sizes of machines—a large number of contractors do not possess this knowledge. This alone shows the necessity for manufacturers to continue their extensive campaigns of advertising and for the journals to continue their educational work.

Within the past two years the author has visited cities of more than fifty thousand inhabitants where not a modern dump wagon was owned by a contractor and but a few concrete mixers. Not a road or street contractor owned a paving mixer, and it has been quite surprising how these conditions have been duplicated in other communities. Then, too, it is of interest to note how, in some sections, certain labor-saving methods are used, while in other localities within a few hundred miles they seem to be unknown. With modern methods of travel and communication our whole continent is comparatively small, but it is a well-known fact that knowledge travels slowly and people are loath to give up old ideas and methods of conducting their business.

There are three distinct lines in which hand methods are used that cause a large annual waste of money. The first is in excavation. There are on the market a very large number of devices and machines designed for all classes of earth and rock excavation. Some of these are designed for handling large amounts of material in an hour and are not suited for small jobs, nor for the odds and ends of a large job. But many of these machines are portable and designed to excavate as little as from 4 to 10 cubic yards per hour economically and can be used in many places where picks and shovels are now employed. The same machines can often have their output doubled or trebled. Then, too, there are a number of machines now meant to excavate where the cutting is light—that is, less than a foot in depth—and yet the total yardage may be large.

In connection with the excavation of rock, small machine drills can be used instead of hand drilling. For unwatering ground, instead of hand pumps for a limited amount of water, power-driven pumps can be used, especially gasoline and electrically-driven pumps.

A second class of work done by hand is concrete mixing. For small jobs there are now on the market many mixers operated by gasoline engines. Such mixers can be used where only a few yards of concrete are needed per day, or they can be used as an auxiliary mixer, where a large machine is used for most of the work. The fact that there is a large mixer on the job should not preclude the installation of a small one.

A third class of work in which much hand labor is customary is in handling and rehandling building materials. Cars and boats are loaded and unloaded by hand. Vehicles are generally loaded by hand, although to-day most of them are unloaded by dumping. Much of the material is rehandled by hand, as in serving it onto structures or into mixers, as with the materials for concrete. For nearly every one of these uses there are certain devices that will save money, the amount varying according to the quantity of material to be handled. For very small jobs it is not always possible to install machinery, but advantage can be taken of some simple devices and of planning the work so as to reduce the handling to the minimum.

Excessive Plant

Next to the shortage of plant, more money is wasted in buying useless machines—not useless from the standpoint of being idle, but rather because it was not necessary to purchase them. In other words, before purchasing a machine to enlarge a plant, the proper procedure is to obtain all the work possible from the old one, or from one unit. This is a statement that must be enlarged upon, for it embraces an intimate knowledge not only of plant, but also of serving machines and the installation of accessories.

The fact that a man has a concrete mixer on a job is not enough. It may be an obsolete pattern, or it may be of a design unsuited to the character of job. For this reason the various manufacturers of concrete mixers are now making different styles of machines, some of them having as many as ten different designs, each for a different class of work. For instance, a concrete mixer adapted to a building job would not be the one with which to lay a pavement foundation, nor one for a heavy retaining wall.

This is not only true of the same makes of machines but also of different makes. Thus a contractor may be using a certain type of machine of one make, and must have an increased output. He buys several others of the same make and still has to increase the number. Possibly if he had substituted another make, one or two machines would have been sufficient. This can be illustrated by two actual examples.

A contractor building a sewer had a half-yard mixer. This did not give him output enough so he purchased another half-yard mixer of another type. The result was that the new mixer gave an output that was enough to carry on the job economically and he was able to sell the old one. This showed that the contractor had not selected the proper machine at the start.

Another contractor had a large filtration plant to build. He installed several mixers for his concrete and, in order to obtain the necessary output, was compelled to increase the number until he had more than a dozen on the job, each being operated on a different part of the work. He needed additional concrete, and at last installed a central mixing plant, served by conveyors. With a large capacity mixer of a different type he obtained ample concrete, allowing all but one of the old mixers to be taken down and disposed of. The small mixer was used to do odd jobs on the outskirts of the large filter plant.

These examples serve to illustrate the point to be made: that a single unit of the properly selected plant may be able to do much more work than a number of units selected

with poor judgment and from meagre knowledge. As it is with concrete mixers, so it is with other apparatus. It may mean not only a greater output, but it may mean, and does in most cases, less investment in plant and also a great saving in labor.

An eastern contractor recently published a statement regarding the tearing up of old pavement and the regrading work, the job was done with a steam roller and plows; wagons were loaded by hand. This method was changed for a small steam shovel, slightly reducing the plant investment, materially increasing the output of work and reducing the daily cost by $15 to $20.

Before deciding upon the purchase of additional machines, besides knowing that the proper kind is being used, the first step must be to learn if the plant being used is operated to its full capacity. A system may be devised to save labor and at the same time improve the service. This may be applicable to hand methods, or it may mean the elimination of hand service and the installation of machines.

A concrete mixer may be producing 100 cubic yards per day (served by hand). Systematizing this service may increase the output to 150 cubic yards. Serving the mixer by means of conveyors or other rehandling machinery and handling its output with buckets or cars may cut the labor costs per unit (by eliminating men) and increase the output to 200 cubic yards per day. The simple expedient of buying another mixer to obtain this additional 100 cubic yards would have meant possibly as large or even a larger investment for plant, and the expense of hiring more men, with the unit cost increased by the added capital invested charged against the 200 cubic yards.

Few men can state that the utmost capacity of a machine has been reached until they have tried in a number of ways to increase the output. Then, too, possibly what they have failed in can be done successfully by some expert. The author, in so simple a matter as operating wheeled scrapers, has increased the output of a gang of six wheelers by one-third by using four horses on a snatch team instead

of only three. This was much cheaper than buying two more wheelers and two extra teams. The investment was much less and the unit cost of excavating per yard was reduced.

Overhead Charges

Too few contractors seem to realize that their general expenses frequently run quite high. In cost keeping such expenses are frequently ignored. Many contractors think from going over their daily field cost records that they are making money; yet at the end of the job there is a deficit.

A few years ago a contractor was building a reinforced concrete reservoir for a steel manufacturing plant. During the course of construction he was ordered to do some extra work. He did as he was instructed, and in rendering the bill he added 10 per cent to his actual cost to cover his overhead charges or general expenses. The contractor had also asked the manufacturing company to do a few small jobs for him. Upon receiving their bill after he had presented his own, he found that the company had added 33-1/3 per cent to the actual cost to cover their item of overhead charges. The contrast was great and the contractor wished that he had been the last one to present his bill.

This example serves to call attention to a very important item in all construction work. The treasurer of the steel company stated that they had kept very careful records of their overhead charges for a long term of years and the charges made the contractor were not excessive but were used in fixing a price on all of their products.

Not only must the general expenses for the job in hand be considered, but many other expenses must be charged against the work a contractor is doing. Thus the cost of bidding on contracts that are not secured may amount to many hundreds of dollars in a year. If superintendents and foremen must be kept on the pay roll in dull times, or between jobs, such costs cannot be easily figured against any particular job. Many other office expenses are in the same class.

On large jobs the general expenses may be a small part of the construction cost—less than 10 and in many cases less than 5 per cent—but on jobs amounting to only a few thousand dollars the percentage will be larger and may become greater than 10 per cent.

Not only is it necessary to have some idea of the possible general expenses when bidding on jobs, but also while a new job is in progress the expense should be figured so as to apply the overhead charges to the daily cost records. This can be done in two ways: by taking an average of these items of expense for the preceding year or for a term of years, which makes the charge a false one, or by an arbitrary charge. The averaging of past expenses is necessary because it is not possible to obtain exact figures until the job is done.

A closer method, but one that makes these charges more difficult to keep, is to make a weekly record of expenses and apply the results thus obtained one week to the next week's daily costs. By this method large expenditures for any item of general expenses will be noticed at once, making it possible to look into the expenditures and curtail them if they are too high.

Keeping the costs in this manner may make the applied cost high one week and low another, but for a season, a year, or the life of the job, the average is likely to be closer than that figured from previous years.

Some items of general expense are incurred daily or weekly, while others are extraordinary, that is, only made at long intervals. The first ones are not often overlooked; the extraordinary ones are apt to be forgotten in making estimates. For this reason the following list is given, not that it is complete, but rather to be used to make up a complete list for contractors engaged in different lines of work:

1. Advertising.
2. Inspecting new jobs.
3. Making up estimates.
4. Bidding upon jobs.
5. Entertainment.

6. Providing bidding bonds or certified checks.
7. Cost of construction bonds.
8. Signing contracts.
9. Planning and routing new work.
10. Subletting work.
11. Employes liability insurance or compensation.
12. Automobile insurance.
13. Fire and other insurance.
14. Cost of accidents.
15. Photographing construction.
16. Office salaries.
17. Office rent.
18. Office supplies.
19. Postage and telegrams.
20. Telephone service.
21. Printing forms.
22. Cost keeping.
23. Outside clerks.
24. Superintendence.
25. Automobiles.
26. Horses for office use.
27. Lights for work.
28. Water for work.
29. General camp expenses.
30. Cost of construction buildings.
31. Watchmen.
32. Engineering.
33. Legal expenses.
34. Traveling expenses.
35. Fees to experts.
36. Salaries paid to hold men.
37. Pensions.
38. Contracting and engineering journals.
39. New books.
40. Taxes.
41. Licenses and permits.
42. Building and maintaining roads.
43. Interest on borrowed capital.
44. Expenses of purchasing department.
45. Personal expenses of contractor.
46. Signs for jobs.
47. Forfeits for delays in completing work.
48. Charity.
49. Life insurance.
50. Contractor's association dues.

All of these expenses do not occur on some jobs, nor do all contractors have the entire list. Many contractors carrying on large operations have the entire list and many additional items.

According to some methods of bookkeeping all of these items will be charged to one account; by other methods they are charged to several accounts. A division of the accounts is recommended so that the various items can be more easily checked up and in order that the aggregate of each account can be known and kept to the minimum.

It is also necessary to keep these expenses for different jobs. Thus there will be general expenses for each job, as well as those that are applicable to all the jobs a contractor may have.

For cost keeping and estimating, the various items must be assembled and so worked out as to apply the overhead charges to each unit of work. This can be done by a direct charge, or can be figured on a basis of a percentage of the unit cost.

Another question to be given consideration is the overhead charges which are the result of a heavy investment in plant. Such charges are quickly increased by buying plant. There is, first, the interest charge on the capital. Then there are repairs and renewals while the machines are being used and the depreciation of the plant, whether it is in use or idle. Such charges and expenses are going on whether the contractor keeps account of them or not.

During periods in which there is plenty of work, the drain of such overhead charges is not felt, for these expenses are chargeable over a number of jobs and form a small per cent of any unit cost. But when hard times come these same overhead expenses become such a large proportion of each unit cost that there is no real profit in the work and the contractor is really living on his capital or past profits.

It is at such times that the real harm of too much plant is felt. The contractor is in the same position as the manufacturer who has built a new factory or an addition to his plant during prosperous times, only to find it idle when a

business depression comes. Not only has he used up available cash, but his overhead is now excessive for the limited business he is doing. It is easier for the contractor, for he may be able to move his plant to a section where there is new work—a thing the manufacturer cannot do.*

These are all items of bookkeeping, but they likewise enter into cost keeping and must be considered in management. Overhead charges due to plant must become a direct charge to the work; but overhead charges due to excessive plant and especially when some part of such plant is idle, must not be a direct charge against any job, but should be handled as a charge against the entire business. In this way it is handled through the "profit and loss" account. In fact, not only is the overhead expense a direct loss against the contractor's entire business but the items of plant that were never needed and can be classed as excessive plant really have eaten up some of the profits, although it is customary to carry such charges in the plant account. Profits come too hard in contracting to be wasted on the purchase of excessive plant. Cash in hand is always worth more than any piece of idle machinery.

In purchasing plant an attempt should be made to keep it uniform—that is, instead of buying one machine of one make and a similar machine of another make, the contractor should, as much as possible, get the same make. It is quite easy to give this advice, showing that uniformity means saving money in operation and in keeping spare parts on hand for repairs and stating other benefits, yet by doing this one will only know by hearsay what are the best makes of machines. Then, if a mistake is made in selecting the first machine, it will be duplicated in buying additional ones. At times new types and makes of machines should be tried out, and these things prevent uniformity being established and maintained. This is the case to-day with contractors adopting automobile trucks. Many a con-

* This subject has been dealt with at some length from the manufacturer's standpoint in a paper before the American Society of Mechanical Engineers by Mr. H. L. Gantt.

tractor is trying out several makes of machines so as to adopt some one make. Results are unsatisfactory during the life of these cars. As it is with trucks, so it is bound to be with many other classes of machines.

Plant Knowledge

In selecting machinery for construction work the contractor must have adequate plant knowledge. This term plant knowledge must be construed in its broadest sense. Only a part of such knowledge can be stored in a man's head, for so many details must enter into it that no one can memorize it all.

Plant knowledge must cover data as to all makes and types, for if a man is ignorant of the existence of any particular type or make of machinery, he is not able to consider these in making his selection. There is always the possibility that such machines may be the best adapted and most economical for the construction under consideration. Yet many successful contractors have meager knowledge of a large number of manufacturers' products and are proud to make such a boast.

To illustrate. A few years ago the author was awaiting his turn to talk with a contractor who was going over with a salesman the matter of selecting some machine for his work. The contractor said: "We are just beginning to consider installing this plant, and we have used your machines. I mean to use them on this job. You can't tell me anything about them, but rest easy, for we will buy from you when the time comes."

This satisfied the salesman and he withdrew. The next man to talk with the contractor was another salesman, representing a company making machines for the same purpose, yet of an entirely different type. Both makes of machines had been on the market about the same length of time and were well advertised.

As soon as the new salesman stated his business the contractor exclaimed in a very emphatic and haughty tone of

voice: "No use talking to me. I never heard of your machine, don't care to now, and I have already decided on the machine I am going to use. I have not time to talk to you." The salesman left.

The author knew both machines, and the one turned down was the most economical in operation and capable of greater output than the one selected in this offhand manner. There happened to be in this contractor's office another contractor having similar work to do on another section of the same extensive undertaking. He, too, had been using the same machines that the other one had decided to install, but hearing the second salesman turned down in a loud tone of voice, he followed him out of the office, talked with him regarding his machine, got a catalogue, investigated the matter and installed the second type, much to his delight when increased profits were earned. The first contractor showed ignorance and pride in his lack of plant knowledge, the second was a man anxious to add to his knowledge and profit by it.

Plant knowledge likewise consists of knowing the method of operating all the various types of machinery meant for the same kind of construction, and the range of work that each will cover. In many cases a machine that will do a wide range of work is a recommendation; in some cases this may be an objection, as the work may be of such a peculiar nature that a special machine should be made.

This is the case in mixing bituminous materials for street and road work. A mixer meant for concrete may be used for the bituminous materials by adding heating apparatus, but it will not give as satisfactory or as economical results as one designed especially for that class of work.

The speed of a machine is as important as its design and operation. The capacity is dependent upon its size and the speed. Two machines of the same make and the same size, geared to different speeds, will give different outputs if operated in the same manner, yet few contractors go into this feature of machines.

Another important element of plant knowledge is the wear

and upkeep of all makes of machines. This is dependent upon the design, the quality of the materials, and the skill and care of manufacturing. A machine that has continual breakdowns is not only expensive in repairs but is the cause of delays and of the necessity for shifting men from one part of a job to another to keep them employed. Such breakdowns may interfere with the entire sequence of the work as planned, and break up of the essential feature of modern management. There are few machines that will not break down at times, especially when they become old, yet there is the greatest difference in this respect in various makes of machines.

The design of a machine and also of its parts has much to do with its breakdowns. A poor design means undue strain on certain parts, with resultant trouble. New types of machines, until they are tried out, are often weak in this respect, but a reliable manufacturer is quick to remedy such details. The advantage some makes of machines have over others is in the simplicity of design. Such equipment is often termed "fool proof," but a more intricate design may likewise be called the same, if all the parts are well designed. At times a simple machine may have a limited range of work due to its design.

No matter how well a machine is designed, if good materials are not used and skill and care are not employed in making the parts and assembling them, frequent breakdowns are bound to occur.

Next to design, this is the important feature of manufacturing. The reputation of a manufacturer stands behind these things. In some important installations of plant it is possible to have test bars taken to see the quality of the metal. Other tests may be made for wood and other materials, and by inspection the skill and workmanship may be tested, but in most cases the purchaser is dependent upon the reputation of the manufacturer. The fact that a machine is guaranteed is a small item. It only means the replacing of a spare part and the saving of a few cents as compared to the cost of an expensive delay and possible

tying up of the job. A reputable manufacturer will make good any defective part as quickly without a guarantee as with one.

Plant knowledge must include familiarity with the cost of machinery. Naturally everyone is anxious to save money, so that a low price is a consideration in buying; but good quality and the best of skill and workmanship cannot compete in price with poor materials and cheap unskilled labor. The purchaser must possess knowledge of manufacturers as well as of their products in order to discriminate in prices. A hundred dollars saved on the purchase price of a machine, if it has cheap materials in it and is manufactured carelessly, may mean a thousand dollars lost on an important job. Quality must be considered in connection with the price.

This is true likewise of supplies and materials used in construction. A contractor's reputation is at stake in these matters and he is like a manufacturer placing a poor machine on the market if he attempts to use materials and supplies of poor quality. A contractor's structure must be of the best if he is to give satisfaction to his clients.

Then, too, the best machine can be ruined by using cheap supplies. Poor lubricants are a hindrance rather than a help to machinery. Poor quality coal is hard on the fire box and boiler and does not give steam at an economical cost. So it is with other supplies.

The details of operation and service of machines of various makes and types must be known if the best and most economical types are to be selected. This knowledge can be obtained only by close study of cost records—not only those by the contractor himself, but also all other records that can be obtained.

Cost Records and Their Availability

Cost records and analyses are necessary to the most efficient management, and in fact these are essentials of modern management on construction work. Nothing is

left to impressions nor to guesses. All methods and systems are based upon actual data obtained from work done. It is easy to sit down and count up the cost of service of a machine and the cost of materials and place a theoretical output of the machine and its crew. By making an allowance for plant and other overhead charges it is possible to show a low unit cost on work and a handsome profit. But it becomes a difficult task to live up to such figures and make the calculated profit. Any inexperienced engineering graduate can do the first; it takes an experienced contractor to do the second task.

Such estimates and cost data are of little value. Contracting cannot be successfully carried on upon visionary statements and calculations. Success can be achieved only when knowledge is based on hard practical facts and results. A man cannot expect to make himself a contractor by purchasing a book upon contracting and one on cost data. Both may aid him but he must possess much actual experience and practice before these things will really help him.

Some men have made this mistake, but generally at such an age in life as to retrieve the loss and profit by it. Many contractors, however, do not profit from the experience of others, nor from information that they can glean from technical journals and books. It is the little details that may mean the difference between success and failure. The success in operating a machine may be dependent upon some small detail of service.

Then, besides the details, there is often the chance of learning from others the great essential of new machines and new methods or the adaptation of an old machine to new work. It is these things that every contractor should be on the alert to learn from others for they become capital to him without the necessity of his carrying on the experiments himself.

A man purchasing a steam shovel for the first time, today has the advantage of fifty years of experimental work and experience of the manufacturers and users. Some

of this is thrust upon him; the rest can be gleaned by study and keeping his eyes and ears open.

Cost records, to be of value in selecting and operating machines, must be analyzed. They must be reduced to working units so as to make comparison easy. This must be done daily. Analysis of costs has, except in a few cases, but little value when made weekly, monthly, or annually, or at the completion of a job. These analyzed costs give plant knowledge, for if costs are proved high, new machines and new methods will be tried and changes will be made until the costs become reasonable.

Analyzed costs not only affect the selection of machines, but also the accessories that should be used to serve it. Thus with a concrete mixer, the cost records should serve as a basis for decision upon the plant needed to serve the raw materials to the mixer and that needed to handle the concrete from the mixer to the forms. Thus it may be cheaper to elevate the concrete to a height of fifty feet in order to chute it a distance five times greater, than to haul the concrete the horizontal distance.

It is also this analysis of costs that results in the substitution of machines for hand methods. For example, if it is found that concrete is being mixed and placed for $1.00 per cubic yard, and the mixing and placing is costing but 30 cents, while the serving the mixer by hand is costing 70 cents, it at once becomes apparent that some handling machine can be installed that may cut the cost of service in half or even make a greater saving.

Plant knowledge based upon analyzed costs also tends to prevent the use of makeshift devices for machines designed and manufactured especially for the purpose. This may mean not only money saved, but also time saved in completing a job.

Special Machines

If, when an unusually large job is to be undertaken, or one having some special feature, the contractor has broad plant knowledge, he and his engineer know without experi-

menting that there is nothing on the market that is especially adapted for the work in question to do it at a low cost. Thus they can at once take up the subject with some expert manufacturer, to design a special machine for the work. The contractor's knowledge of operating machines coupled with the manufacturer's knowledge of designing and building will produce a machine that will in no wise be an experiment, but one that will be a success from the start.

In this connection, due to a lack of plant knowledge on the part of contractors, some are continually asking for a special design of machine for their work, and insisting upon having it, when a regular machine would cost less and operate more economically. In many cases this happens before a contractor has ever used such a machine. Every reliable manufacturer is willing to build special machines, or to make changes in his regular ones, but he has learned from experience which are the best types or sizes for different classes of work.

When a special machine is needed money is saved by the contractor co-operating with a manufacturer in designing it. The latter can substitute many stock parts that will answer the purpose and be cheaper than making drawings and new patterns for designs that do not possess special merit.

One common mistake made in operating plant is the use of machines meant for heavy work or for large capacity, for small things or where a smaller capacity is needed. If only 10 cubic yards of concrete are needed in a day money is wasted in using a 1-yard mixer. A small mixer should be used which needs only one or two men to serve it.

Recently a contractor operating a crushed stone quarry on the outskirts of a large city sent a 5-ton motor truck to carry a few small pieces of machinery into the city and perform several errands. Questioning brought out the fact that nearly every day this service was performed—sometimes twice a day. This being the case, it would have been economical to have had a small truck of 1-ton or less

capacity, and to have used it instead of the large truck, or even to have used a horse and delivery wagon. Even if the larger truck was not needed for hauling crushed stone, it would have been cheaper to use the smaller truck, for neither would be using up money when idle. As a rule, this service was performed at the cost of delivering a load or two of crushed stone. There may be occasions when it would be cheaper to use the larger machine, but these are exceptions.

Plant is used for two purposes, to do fast work and do it at the lowest possible cost. These results can only be obtained by using the machines best suited for the work, and then selection and economical operation can only be based upon adequate plant knowledge.

CHAPTER VI

THE APPLICATION OF MOTION AND TIME STUDIES

Although time and motion studies are essential to scientific management, neither can be termed a basic principle of management as they deal with details rather than with the principles of handling men and machines.

Time studies are those made of the work of men and machines by using a watch. A stop watch is preferred in most cases. Such studies give some beneficial results when made during short periods of time—a minute, a quarter of an hour or an hour. Studies covering longer periods of time, such as several hours, a day or even a week, give results that are more efficient. Time studies of various kinds of work are often made before motion studies, and sometimes to the exclusion of the latter, when, to obtain the best results, motion studies should have been made first.

Motion Studies

Motion studies can be made of machines to better the designs and increase the output, but for construction work motion studies are generally confined to the operations of men. The object of motion studies is to save time and eliminate all useless and waste motions. In reality the two studies should go together when the work of men alone is being considered. The need of making motion studies first is shown by an actual example.

An efficiency engineer spent several weeks in timing the work of a gang of bricklayers. The result of his studies shown to the contractor, who was formerly a bricklayer,

was deemed to be useless by the latter, for he knew from personal experience that many of the motions of his bricklayers were wasteful and some even useless. Accordingly he had a series of motion studies made, and after eliminating a number of the ordinary bricklayer's motions, he was ready to have a series of time studies made of the proper motions, as a basis of obtaining more rapid and economical work.

Motion studies are more difficult to make than time studies, and if experimental work is to be done in order to find out what motions should be eliminated, and how others should be changed, it is hardly possible to prevent the workmen from knowing that their every movement is being watched. It is possible, in many cases, to make time studies without letting the men know they are being watched. The author has had time studies and records of men's work made over periods lasting several months without the gang knowing it. Most workmen dislike to be watched and timed and such practices have caused strikes. For this reason these things should be done with great care and judgment.

In some cases motion studies can be made by selecting a few intelligent and trustworthy employes, and explaining to them the value of the studies to be made. The motion studies can then be made in private. This may answer the purpose for some kinds of work, but for most of the various classes of work, the most satisfactory results can be obtained only by studying work actually being performed from day to day. If the making of motion studies in the open is to break up an organization and cause expensive strikes, such studies had better not be made, except where they can be made privately. However, if a contractor is willing to share the extra profits with his employes he will probably gain the co-operation of his men, which will make his task easier. Their interest will be aroused and they will support him in bringing about more satisfactory results.

Motion studies embrace, not only the work of individual workmen, but frequently that of two and sometimes an

entire crew, depending upon the character of the work and whether it is performed in whole or in part by one or more men.

Unless a contractor is able to get the results of motion studies made by other contractors and use some or all of them, it is necessary for him to make studies of all the various kinds of work done by his employes. Unfortunately but few of those who have had motion studies made, have made public such records and data.

Motion studies can in most cases be recorded in chart or diagram form, or be written as a description. This last method is not so easily grasped as the former, nor can it be used for study so easily. Photographs are a great aid in making motion studies and by them both the right and wrong motions can be shown to the workmen.

As the main object of such studies is to simplify all work and to increase the output of each man, it is necessary to study the motions made in doing all classes of work, even to making studies of picking, shoveling, and the handling and placing of brick, concrete, etc. Such studies must be made for every purpose for which a tool is used. For instance, a man should use one set of motions for shoveling dirt but he should go through a different set for cutting down dirt, or the loading of a wagon. These motions are all different from those necessary when using a shovel for mixing concrete on a board.

Many contractors and their general managers who have not made motion studies are skeptical as to the need of them, and of results to be obtained. They feel that the entire matter is entirely too academic. They do not realize the value of motion studies until they have made them and saved money by applying them.

A short time ago the author was being shown through the addressing room of a publishing house. In a very large room a number of girls were addressing envelopes or small circulars. No attempt had been made to systematize this work as to the motions of the operators or writers, nor to make the arrangements convenient for them. In order

to get a large number of the girls in the room, long, wide desks, at which half dozen or more girls could write had been placed. These desks prevented quick work. The girls were reaching from six inches to eighteen inches to dip their pens into the ink. Likewise each girl placed the pieces to be addressed any place she wished. In some cases this made the distance to be reached a foot or two. Some of the girls made a useless motion to place the addressed article out of the way. These girls, accustomed to the work, were addressing a large number of pieces in a day, but a study of their motions, the supplying of different desks and other paraphernalia would have made the work easier and materially increased the output.

Some years ago the author was in charge of from 50 to 100 men doing similar work. By a close study of the motions necessary to do the addressing and making certain changes in the desks used, it was possible to about double the daily work of each writer. This effected a decided saving, not only in the cost of addressing, but also in cutting down the number of employes and the amount of office room devoted to this work.

The same principles can be carried into construction and the results obtained will be gratifying to those who try them.

After making motion studies of the operations of men, time studies of both men and machines can be made. In some cases the studies are a combination of both man and machine work, while at other times each must be timed separately. Time studies are of use for two purposes: first, to decide upon the proper and best methods of doing work; second, to obtain a standard of work to be done.

Time Studies

Time records will show a great variety of results. Exceedingly favorable conditions exist upon some occasions, allowing rapid work to be done and obtaining large outputs. Then again, work will be held up by adverse conditions and

time records will show up accordingly. These facts alone show the need of time records to prevent the occurrence of adverse conditions whenever possible.

Some years ago the author made some time studies of loading two-horse wheel scrapers on railroad construction. He found, first of all, that when the scrapers were being loaded rapidly in well plowed clay ground the scrapers were not filled by the teams, except by traveling a longer distance than necessary. Thus the time of loading was unnecessarily long or the load was too small. Three horses were being used in the snatch team, as was customary in that section of the country.

This led to the conclusion that with more power, the scraper could be given a larger load and loaded quicker. It was found that the plow was loosening about 8 inches of material in the main part of the furrow. The plow was accordingly set to loosen 10 inches of material and four horses were put into the snatch team. It was then found that the pan could be filled in very little more distance than twice the length of the pan. The snatch team, which at first was hitched four abreast was stopped as soon as the scraper was loaded and remained standing where they were. The scraper team was turned abruptly to one side, pulling the load out of the row. Then as a second scraper team pulled up into the row to be loaded, the snatch team was backed a few steps to be hitched to the scraper before the pan entered the earth, so as to go full force into the dirt and take on a heaping load.

This method, suggested by time studies, reduced the time of loading and increased the load taken by each scraper. Yet a continuation of the time studies showed two extreme conditions. At the end of each scraper row the plow, both in starting and finishing the furrow, did not go as deep as in the rest of the row, and as teams would have to travel over this loosened dirt it was not considered good policy to leave it there. At the same time the studies showed that the scrapers, for a distance varying from 25 to 50 feet on each end of the rows, were loaded much slower, and also with a

smaller load. A great deal of time was spent in trying to improve the plowing, but this was not found to give the results desired, although some improvements were made in this line.

Then another expedient was tried, which was successful, as the continued time studies showed. The four-horse snatch team was changed from being hitched abreast, to being hitched in two teams, one in front of the other. By this arrangement little if any difference was noticed in their pulling power. Two men were still used to handle the snatch team. It had also been found expedient with the deep plowing to have two men hold and load the scrapers. When the dirt was deep in the middle of the rows the four-horse snatch team was used in loading the scrapers, but as soon as the end of the row was approached, one of the loaders and two of the four horses on the snatch team were sent to start a new row, while the other loader and the remaining two horses finished out the row. By the time this was done, the new row was well started and both teams operated together. The results thus obtained were found to be satisfactory as two lightly loaded scrapers were taken out in the same time in which formerly only one had gone out. Then, too, the run of the scrapers was not interfered with as much as formerly, for the foreman was able to direct the scrapers to the new row without waiting for the old row to be cleaned up to the end. Time studies on this work increased the output of the scrapers over 20 per cent, adding but little to the daily cost of the crew, and reducing the unit cost of the excavation nearly two cents per yard.

This shows the necessity of taking the maximum output, and the most favorable time records as the standard to work to, rather than ones that can be obtained ordinarily. Many contractors make a favorable run on their work, and feel certain that this cannot be duplicated for a long time until conditions once more become ideal. This is wrong. A time study made of this favorable run enables the contractor to analyze the work and the condition surrounding it. Then time studies of the same work under other con-

ditions will permit analysis to be made so that many changes can be made, adverse conditions overcome and the work improved to raise the standard and make record runs possible on many days when the work would ordinarily drag.

Cost records must not be confused with time records and the keeping of one does not do away with the other. Cost records should be kept continually but time records need only be kept from time to time, first as a basis of analyzing cost records and second as a means of reducing costs and placing the work on a more economical basis. Thus time records are supplemental to cost records.

Construction work time studies must be made more frequently than in carrying on a manufacturing enterprise for in construction the same operations are not carried on day after day, men in the crews are continually changing, and many details are radically different from manufacturing. Thus one set of studies made throughout a manufacturing plant may be used for years as the standard for that plant, while in construction certain kinds of time studies may have to be made for each job and sometimes several times on a single contract. There are some phases of construction on which the work may be considered standard, and studies once made become a basis for standardizing that phase of the work.

This was the case with the studies referred to regarding scraper work. It is the same with men mixing concrete on a board by hand, or shoveling dirt into a dump wagon of the drop bottom type without sideboards. These and similar things should not vary much from job to job or in different sections of the country. This, however, is not always the case in machine operation as is evidenced by a handbook published and sold by one of the companies manufacturing steam shovels,* showing a wide variation in time records of the same types and sizes of shovels on different kinds of work.

This handbook is an excellent reference book for every

* The Bucyrus Company, of Milwaukee, Wis.

contractor who operates steam shovels although the book would be of more value if motion studies had first been made, and conditions bettered to show more nearly what could have been obtained with the shovels operating under more economical conditions.

However, with these records, and time studies made by a contractor of his own shovels, being served in different ways, many deductions could be made and the methods of operating shovels improved.

Both time and motion studies can be made by young men with but little training, but these same men cannot analyze them and use them as a basis of improving work, until they have gained experience in construction. Allowing the men who make the studies to assist the more experienced men to make deductions and changes and put the knowledge so gained into practice will enable these recorders to handle some of the details themselves and ultimately to handle this department. But with these things, as with cost data, it takes men of experience and sound judgment to use such records.

Motion and Time Studies Applied to Shovel Work

Man has used some form of a shovel since prehistoric times. Digging into the earth for many purposes has always been one of the vocations of man. The development of the shovel has been slow and gradual, while the handling of the tool has been along the line of precedent, little thought being given to its use. The shoveler has always been looked down on, his work being more a matter of physical strength and endurance than one for study and scientific investigation.

Today, however, the cost of shovel work is so tremendous (running into many millions of dollars annually) that the kinds of shovels to use and the methods of handling them merit careful study and investigation. For about 20 years the author has followed this subject closely, making many studies of this class of work, keeping records, timing

men at work and following the investigations of others. As a result, it has been found that it is an extremely easy matter to improve the methods followed by most contractors, and the improvement is so pronounced that it is readily possible to cut down operating costs from 10 to 50 per cent. This would mean the saving of many thousands of dollars yearly and contractors can no longer afford to ignore such facts. It is incumbent upon them to eliminate such wastes. Some of this work must be done by experts, but much of it can be done by contractors and their general managers without assistance, as the general principles are simple, and a great part of the work is only to furnish the proper tools.

All shoveling tools can be divided into two classes, according to the length of the handles: the long-handled shovel, with a straight handle, and the short-handled tool, with a hand grip on the end shaped like the letter "D," and for this reason sometimes called "the D-handle." For ordinary purposes the hand grip is made of wood, but an iron "D" is sometimes used, meant to make the handle stronger and to allow dirt or gravel to be tamped with the handle under ties or sills. This is called a tamping shovel and is employed in railroad construction and maintenance. These iron "D"s are also used to repair the handles of the ordinary shovels, when the wooden "D" becomes broken. A wooden "D" should never be used for tamping, as this, even in earth, will split the handle—and a handle once split retards a man's work.

In the United States and Canada the short-handled shovel is in almost universal use. Few contractors use long-handled shovels, for they are considered a lazy man's tool. The author is informed that in Continental Europe the preference is given to the long-handled shovel. Some Italian contractors use long-handled shovels exclusively, even in the United States. Photographs of European soldiers digging trenches show that most of the men are using long-handled shovels.

It is but right to say that each shovel has its place, but the long-handled shovel should be preferred for most work, especially for excavation, in loading cars, carts, wagons and in any work in which the material must be elevated, such as digging trenches and pits. The hardest work a man does, measured in foot pounds, is in elevating a load. Thus it stands to reason that if this work is done by means of a lever the longer the lever, up to the size and weight that a man can readily handle, the easier the work. The easier the task, the quicker the work can be done and the larger the amount that can be done in a given time. The operation of a shovel is not on the principle of a true lever but resembles it for most purposes.

Long-handled Shovels

In addition to this, actual practice has demonstrated that a man can shovel more earth with a long-handled shovel than with a short one, except under certain conditions where space is limited and short-handled shovels are necessary. For cutting down piles of dirt, for unloading flat cars and for other purposes where the shovel is used with a downward, instead of a sideways motion, the short-handled shovel is the ideal tool. For all side casting and loading the long-handled shovel should be used, unless men are placed so close together that the length of the handle interferes with another man. In loading a one-horse dump cart, the author has loaded a cart with three men using long-handled shovels in a few seconds less time than four men could load the same cart with short-handled shovels. This shows a saving in loading of more than 25 per cent.

The same is true of wagons and other vehicles. Another advantage in loading wagons with long-handled shovels is that men can be placed farther from the wagon than with short-handled tools. Thus more men can be placed around the wagon to load it, the work is done quicker, and team

time is saved. As each man will handle more dirt with the long-handled shovel, the cost of loading per cubic yard will be less, as well as the cost of transportation. These two costs will likewise reduce the other costs, as can be illustrated by the following example:

Some years ago the author was excavating cellars by hand, loading dirt into dump carts. From his cost records he concluded that one man picking was not needed. Therefore this man was changed to shoveling. This reduced the cost of picking only 2 mills or one-fifth of a cent per cubic yard, but the man put on the shovel loaded 14 cubic yards, thus reducing the loading cost, the transportation cost, the cost of dumping and the foreman cost, making a total reduction per cubic yard of 2½ cents and about doubling the profit on the job. This is a striking example of a slight change effecting a large saving per day amounting to hundreds of dollars in a year. Waste was eliminated as the same number of men were employed at the same wages.

This is the principle of saving by using long-handled shovels. For trench excavation, long-handled shovels should be used except in confined places—around manholes, pipes and other obstructions. In opening trenches some contractors use short-handled shovels until they get to a depth of about 3 feet, then change to long-handled tools. This is a mistake. Starting the trench with long-handled shovels, the workman will shovel more dirt and with the same effort will cast the dirt from 2 to 3 feet farther from the trench, thus allowing the pile of excavated material to be made much larger without so much rehandling as will have to be done with short-handled shovels. The saving effected in this manner in any trench work is considerable. In excavating deep trenches, the height of each lift can be considerably increased with long-handled shovels. This also means less rehandling and fewer men employed for that work, allowing a gang of a given size to excavate a greater length of trench in a day.

The Shapes of Shovels

Next to the length of handle, the shape of the shovel is of importance. It is evident that various classes of materials need different shaped shovels. Though some contractors give attention to this, the majority of them do not even furnish scoop shovels to handle coal. Each class of material, such as earth, rock, sand, cinders, coal, snow, and many others, call for a different shaped shovel, while such materials as crushed stone are more easily handled with forks, which can be classed as shovels.

The first great distinction in shapes is for digging. The ordinary shovel is not meant for digging, but simply for picking up loosened materials. A special shape is given a shovel meant for digging, such shovel being termed a spade. The blade is made heavier and much flatter in shape, and is bound on its upper edge by a heavy reinforcing piece of metal. This is to strengthen the blade and give sufficient foot rest to force the spade into the ground. These tools are made both with long and short handles.

Both loam and clay can be loosened and shoveled with a spade. The more plastic the clay, up to a point that will allow the clay to break away from the mass, the larger the load that can be handled at one time. Damp soils and clays spade easily. Exceedingly plastic clays—those that are tenacious and do not break away readily from a mass when dug with picks or mattocks—can be cut into large chunks like adobe bricks with a spade and handled cheaper than with a shovel, as the flat pieces lie better on the blade of the spade.

Spades are not used much by contractors and are not often needed, but there are certain kinds of soils that can be excavated cheaper with a spade than with picks and shovels. This is especially true of trench work. Upon one occasion the author had a small contract for laying sewer pipe. He had in his employ eight men, three being kept busy loosening the clay with picks and five shoveling. The

clay was fairly stiff but free from stones. After a few days long-handled spades were purchased, the picking was stopped and each of the eight men dug and threw out of the trench as much earth as each of the five had done before. A saving in trench excavation of 37½ per cent of the cost was effected.

In casting up low railroad embankments from berm ditches, the author has saved much money by the use of spades. Every contractor should be on the lookout for favorable places where spades can be used for excavation. The diamond-pointed spade and the diamond-pointed shovel are used for breaking down coal and other materials. A spading fork with flat tynes is used for turfing and turning light soil.

Sand does not need digging and a spade is not suited for loosening and shoveling it. Instead, a large, square-pointed shovel with slightly curved or turned edges, should be used, as the load lifted will be much larger. If the sand is moist (not saturated) more will stay on the shovel and thus the excavation is done cheaper. This is the case both with sand in its original bank or when placed in piles for concrete or other purposes. Any light and soft earth can be spaded with a well-made shovel. The tool should have a square point and be of such width as to carry an economic load. For this kind of work a shovel with a strap on the upper edge should be used. This gives a foot rest and allows the foot and leg to be used in digging, the shovel being held, instead of forced, by the hands and arms.

In ordinary shoveling a man should not be allowed to place his foot on the shovel. It is a useless motion and only delays him. The only reason for using the foot is that the material is not properly loosened. If that is the case the foot digging should be stopped and a pick used.

For very plastic, wet, heavy clays, a skeleton spade should be used. These tools are used extensively in the upper Mississippi valley for digging drainage trenches for placing under-ground tile drains. They consist of a cutting blade a few inches deep with ribs leading from the

blade to the frame around the eye into which the wooden handle fits. Thus the tool is shaped like a spade, but in looks is like the skeleton of one. This prevents great suction of the water on the blade, making it heavy for the operator handling the tool. The spade is made in varying lengths to suit the depth of the trenches. There are a number of special shapes of spades or digging tools designed for special work of digging post holes and for ditching and drainage. Some of these are meant to be operated by several men.

In using ordinary spades and shovels in wet soil or sand suction on the blades can be prevented by drilling several holes on each side of the handle. Such holes should be from 1 to 2 inches in diameter.

For ordinary earth, a square-pointed shovel, rather flat, with turned edges, should be used. This shape is ideal either for wet or dry soils, or for light, flaky loam or clay that breaks up in lumps. The shovel must not be expected to do the work of a pick, and a man cannot get a good load on his shovel if the ground is not well loosened and plenty of the loose dirt kept in front of the shoveler. Upon one occasion, where shovelers were working with only a small amount of loosened dirt in front of them, it took an average of thirty shovel loads to fill a wheelbarrow. At the author's suggestion that more loosened dirt be kept before the men, and without mentioning the subject to the shovelers, a wheelbarrow was loaded with an average of twenty shovel loads and a decided saving was made without increasing the cost of picking.

Height of Shoveling

The height to which the shovel load is raised is an important item. Up to a certain height there is not a decided difference. For instance, a man can cast more dirt a reasonable horizontal distance than he can raise a reasonable vertical height. In raising earth up to about 30 inches, a foot or more in height does not make any decided difference in cost,

but the next 2 feet in height will reduce the amount of earth handled by 10 per cent. Thus for 4½-foot heights the cost of loading will be 10 per cent more than for 2½ feet. The ordinary drop-bottom dump wagon without side boards is 4 feet 8 inches high, and for efficient work this should be the limit of height, for every 6 inches in height above this means a reduction of 10 per cent.

A man trimming a scow, car or stock pile, where the material is not over 30 to 36 inches high, will make an average of twenty shovel loads per minute. This may be partly casting and shoveling but not all the shovel loads will be raised to the top of the mass.

In casting in average earth not exceeding a horizontal distance of 10 feet, a man will make an average of eighteen shovel loads.

In loading wheelbarrows, dump-buckets, dump-carts without tail gates or low cars a man in average earth will make an average of fifteen shovel loads. The height of these will not exceed 30 to 33 inches.

In loading dump wagons without side boards, slat bottom wagons or any car not exceeding a height of 4 feet 6 or 8 inches, a man will handle thirteen shovel loads. To add 6-inch side boards to these vehicles will mean to reduce the number of shovel loads to eleven.

In loading the high rear end dump wagons used extensively in New York City, having a height of from 5 to 6 feet, the average shovel loads handled by a man will be nine. To add 6-inch side boards will reduce the number to seven.

In loading the rear end, 2-horse 4-wheeled dump carts used in Boston, Mass., with high side boards and tail gates reaching to a height of 7 feet a man will load but six shovelfuls per minute. All of these are records in good shoveling materials well loosened and for a period of one minute. Short-handled shovels were used.

These records are not theoretical ones, but are the results of actual timing. They represent the work good shovelers can do and should be made to do if possible. On many

jobs the number of shovelfuls is much smaller. This is due to inefficiency on the part of foremen and to a lack of knowledge on the part of the men.

If long-handled shovels are employed the number in each case would be increased 10 per cent. The author has records for long-handled shovels for all but the last two cases, and bases his judgment for these upon the first named cases.

Few contractors seem to know these facts or realize their importance. It can be seen from these records that if attention is given to the height of vehicles much money can be saved in shoveling.

Shovel Shapes for Various Materials

For earth mixed with rock or for rock broken into irregular sizes, as in a quarry or open rock cut, and for very heavy earth, a round-pointed shovel with a decided curl to the blade should be used. The pointed blade seems to be able to cut under the rock more easily, and the curl holds the load better, except where the rocks are 6 inches or more in size. When there is much of this size of stone and little or no earth or fine stuff, a flat stone fork should be used. It is possible to have both a fork and a shovel handy for each man to use.

Flat stone forks, with the two outside tines raised above the rest, are better than shovels for handling stone, except to clean up a pile. A three-quarter length handle makes handling easy and the tines go into the pile or under it more easily than does the solid blade of a shovel. However, for some concrete work and for road construction in some states, engineers will not permit the handling of crushed stone with forks, as the smaller sizes are likely to fall through the fork, causing them to remain at the bottom of the pile.

Thus for concrete and crushed stone shoveling a square-pointed shovel with the edges of the shovel turned up should be used for small sizes of crushed stone or run of the crusher,

or for fine gravel, chert and similar materials. For the larger sizes of stone, a flat, round-pointed shovel with the sides turned up should be used. It is not proper to use the same shape of shovel for all grades of concrete. For shoveling stone on board platforms a square-pointed flat shovel should be used.

For sand, especially if moist, a flat wide shovel with the edges curled should be used. It is nearly always possible to moisten sand for shoveling. When this cannot be done and the sand is entirely free from loam and runs easily, a small size scoop shovel should be used. However, as the scoop is likely to weigh more than the flat square-pointed shovel, the latter should be used if it will carry an economical load.

Iron and steel moulders use a light flat square-bladed shovel made especially for their use. It is either a strap shovel or a hollow back tool.

A scoop shovel should be used for cement. Inasmuch as cement is now being handled in bulk and also some of the small concrete mixers are being fed with cement by shovels, the subject of shoveling cement is of importance. A flat shovel will lose part of its load and the least breeze will blow some of the cement away. In shoveling cement two points must be kept in mind: the economy of the load handled, and the prevention of the waste of cement.

Cinders and ashes should likewise be handled by scoops. The flat shovel cannot carry an economical load.

Coal should be shoveled with a scoop, but as different grades of coal are used by contractors, it is necessary to get different sized scoops in order to handle an economical load. Miners in the south use a broad flat shovel for coal. It is seldom that more than one or two different kinds of coal are used on the same job, so this is not an expensive proposition. When coal is being shoveled from a car or a bin, from on top, a breaking-down scoop should be used in one corner until the bottom is reached. Then the regular shovel should be brought into play. A breaking down

scoop has a long sharp point and is made round and not so flat as the ordinary scoop.

Only a few contractors use coke. This should be handled with a fork, unless the coke is broken, when a shovel similar for handling rice coal should be used.

For handling street sweepings a large scoop with a broad mouth should be used so that the last of the pile can be swept onto the blade with a broom.

For snow a light-weight, broad, flat shovel is best. The edges should not be turned much, otherwise the snow will break off from the pile at the edges. If the edge is kept low the snow will stick out over the blade on each side, giving an increased load. For piling snow, a Toy street scraper is much more efficient than a shovel as it will gather up a large mass of snow and push it into a pile. A wooden scraper can be used by a man in a manner similar to the Toy. A precaution in using these scrapers is not to have the piles too far apart, otherwise the men will walk too far and lose part of their load. In a street of ordinary width scrapers can be used to push a fairly heavy fall of snow into two windrows, and other men can put the snow into piles with shovels if this is necessary. For throwing snow into sewer manholes these scrapers are superior to the shovel, as all that does not enter the hole when the vehicle is dumped can be quickly pushed into the opening with the scraper.

Snow sticking to a shovel or scraper can be prevented by dipping the tool in water. In exceedingly cold weather this cannot be done as the water will freeze. Another expedient is to wax the shovel. A small charcoal or gasoline heater will quickly take the chill off the steel blade so that a little wax can be rubbed on the inside, causing the snow to slip off. For shoveling ice a regular ice scoop with holes bored through the blade should be used. These holes are a great aid in preventing the freezing and caking of the ice on the blade.

For placing sand, grit, quarry dust or pea stone on a bituminous road a square-pointed flat shovel should be

used. The load carried in this case is not so important as is the even distribution of the material on the tar or asphalt. The load must not be thrown off the end of the shovel, but over the side giving the shovel a motion forward and sideways at the same time. To throw the material over the end of the shovel means to cast it into ridges or little mounds, not distributing it evenly over the surface. Men must be trained for this work, which is becoming very common. The material must be thrown only onto the strip of bitumen. To throw it across it and onto the road surface where the bitumen has not been placed means to waste it and, worse still, to dirty the ground surface so that the bitumen may not stick, but will ball up to some extent.

Very fine gravel should be handled with a scoop; coarse gravel should be handled with the same shaped shovel as is used for crushed stone.

Bituminous road materials, especially those hot mixed, should be handled with close-tined forks. A shovel fouls itself quickly with the hot mixture, while a fork does not do so to the same extent. A shovel should be used to scrape out the wagon or truck if this becomes necessary. A more economical method of spreading and handling the hot stuff is to spread it out as much as possible in dumping the vehicle and then use rakes to spread it over the street or road. This is done with greater ease, and only a small amount of it may need shoveling. Even cold mixed bituminous materials are handled better with a fork.

For handling broken sod or turf a spading fork is better than a shovel, unless it is desired to move the dirt or soil with the sod. This is seldom the case, for as a rule it is desired to separate the sod from the soil as much as possible. A fork not only picks up the sod better, but assists in removing the dirt, as the fork can be shaken easily and the dirt will fall through the tines.

Manure should be handled with a fork, except when it has much sawdust or light shavings in it. Then a shovel similar to that employed for handling snow should be used. The manure fork is much lighter than those used for other

purposes. For piling manure or taking it from a pile, a heavy manure hook should be used, this being similar to but heavier than a potato digger.

For handling sawdust a scoop shovel should be used, which is a light weight scoop of large capacity.

A similar scoop is also employed for shoveling grain. Both of these scoops have hollow backs to make them lighter.

For shoveling dirt from deep holes a round-pointed short-blade shovel with a specially long handle is used. For cleaning out the bottom of such holes a spoon-shaped shovel is used. These spoons cannot be used for digging as the other shovels are. Such tools are called telegraph shovels and spoons, as they are used extensively to dig holes for telegraph poles.

Size of Shovels

The third factor governing the selection of a shovel for any class of work is the size of the blade. Thus, there are three governing factors: First, the length of handle; second, the shape of blade; and third, the size of blade.

From tests made some years ago by the author he concluded that an economical load for a shovel to carry in construction work was about twenty pounds. The late Frederick W. Taylor decided upon a twenty-one pound shovel for handling ore, earth, rock, coal and other materials, most of which are handled by contractors. Inasmuch as this standard has been accepted by some, and shovels are being manufactured for the different materials to carry this load, the author has adopted it as his economical load and recommends it.

Scoops and shovels are made in sizes from numbers 00 to 12. The scoops are furnished in all of these sizes while the shovels run from size 0 to 8, the most common sizes in use being Nos. 2, 3 and 4. Most manufacturers make these sizes but a No. 2 shovel made by different manufacturers is not always exactly the same size.

These sizes are supplied in different types of shovels such as square and round-pointed, scoops, spades and forks. Such sizes are not determined upon with a viewpoint of carrying a scientifically gauged load, but to carry a fair load and meet a popular demand.

In order to obtain a shovel carrying an average load of 21 pounds in different materials, it is evident that the size of the blade or bowl must vary with the class of materials to be handled. If we are to adopt this standard we must give up numbering the sizes and refer to shovels by naming, lettering or numbering the sizes for different materials making shovels known as rock shovels, earth shovels, concrete shovels, soft coal scoops, etc. One manufacturer has adopted this method and ultimately the others may come to it if contractors and other shovel users learn the meaning of an economical shovel.

The laborer using a shovel puts forth so much energy in an hour. Give him any shovel—even one that is half worn out—and so long as it does not bother him he will continue to work with it even though the shape and size may be wrong. He is working for wages and cares little about the tool he uses. Consequently the tool must be changed. The handle must be made of such length as to allow him to work with more ease and rapidity. The shape should be such that the shovel will hold its load withuot spilling part of it, and the man can drive it into or under the material easily. Make the size such as to shovel a cubic yard in a hundred loads instead of one hundred and fifty, and it is evident that the man's work will be decidedly increased in spite of himself and in many cases without his knowledge. Put an economical tool into a laborer's hands and offer him a bonus and the increased money he will earn for himself will be small compared to the extra profit he will make for his employer.

In considering the proper load for a shovel, it must be borne in mind that the economical load decided upon is the average for the average man. Thus a man using a 21-pound shovel will move, in whatever class of material he is

working, that number of pounds (average) at each shovel load. If a man cannot handle such a load and keep up with his co-workers he is not suited for economic shoveling and should be placed at other work. This is a part of shovel management. A man may be a poor shoveler, but a good picker; he may be suited to working on the dump, or sloping or dressing up. It is seldom that a man is utterly worthless.

The blade of a No. 2 shovel is approximately 10 inches wide and 12 inches long. This is for a square-pointed, plain black or polished shovel. A round-pointed shovel is generally made about an inch longer and half an inch narrower. The two shovels, if of the same size or number, will hold the same load in the same class of material. Sizes of shovels differ, according to the manufacturer's designs, but it will only be by the fraction of an inch.

In shoveling ordinary earth, it takes about one hundred and fifty shovelfuls to make up a cubic yard of earth, loose measurement. The average load on a shovel of this size is from 12 to 13 pounds. As the economic load is 21 pounds, the No. 2 shovel load is but 60 per cent of this economic load. This means that a properly designed shovel for average earth will carry 1⅔ times the load of a No. 2. Consequently it will take but ninety shovel loads of such a shovel to make a cubic yard. Add a long handle to this shovel and the amount of work is further increased.

These are theoretical figures for the man who knows how to shovel and they cannot be obtained from every man. It is, however, an easy matter to increase the work of any laborer 50 per cent or more by simply placing the proper tool in his hands.

Only recently the author was asked by a contractor to point out where he could effect savings. It was suggested to the contractor that he could save money in the shoveling, for the contractor's men were using well worn No. 2 shovels, taking hardly half the economic load. The contractor replied that he expected to make certain improvements in the work himself, but it is a safe guess that these same worn

down unsuitable shovels were used on another job. Certain improvements that a contractor intends to make himself are seldom made, for he seldom has time to consider details.

The Motions of Shoveling

Few laborers know how to shovel. Why should they? They have not experimented with the shovel and no one attempts to teach them. The day this chapter was written the author watched and timed six men loading wagons with short-handled shovels. Only one of the six knew the correct motions. He, with the same ease that the other men employed, threw three more shovel loads per minute than any of the other five men.

Every contractor and foreman should know the correct shoveling motions. Shovelers are known as right and left hand shovelers. The right hand shoveler casts his load from his right side; the left-handed one from the other side. The motions of the right hand shoveler will be described.

With a D-handle shovel the man grabs the "D" with his left hand, allowing the cross of the "D" to lie in the palm of his hand. With his right hand he grabs the shovel handle at the top of the iron straps. Standing alongside of the material to be shoveled, he bends his back and puts shoulders forward. It should not be a decided bending over, as in picking up an article from the ground, otherwise the man is not well balanced on his feet and his motion is too much to one side.

As he makes this bending motion his feet are placed apart, his right foot being close to the material and pointing directly towards it. The left foot is kept from 15 to 18 inches to the rear of the right, forming with it at the heels nearly a right angle (see Fig. 1). The right arm at the wrist is laid on the right knee and the knees are bent as the shoulders and back are bent over, giving the body a decided squatting motion. At the same time the shovel is thrust forward, allowing the left hand to come inside of the

man's left leg just above the knee and well against it. At the same time the whole body and the knees are given a decided forward motion, assisting the man's arms with the weight of his body and the thrust of the knees (and especially the left leg) to force the shovel well into or under the material. These motions are not only more effective in loading the shovel, but also not as hard on the man as when only the force of the arms and back is used.

The shovel being full, the knees are straightened and, without straightening the back decidedly, the body is turned slightly. With the hands in the same position the load is cast away. The casting motion is used only when the height does not exceed 3 to 4 feet and the horizontal cast is only a foot or two. When the height is greater, the man's back must be straightened up and his feet brought together, all of these motions being made at once with a decided swing of the shovel so as to give the material force enough to carry it to the desired height. To cast from the man a distance of from 5 to 15 feet, means to straighten the body, raise the arms to their natural position, giving them first a back swing. Then, as a step is made forward with the right foot, the arms are thrown forward, and the load is cast. If the material is to be cast to a considerable height and distance, it is necessary to combine these two sets of motions.

No matter what the shape or size of shovel or handle length, to throw material these excessive distances means to cut down the amount of material that a man handles per day. No one must expect, by purchasing a shovel of the proper size and pattern, to obtain the best results if attention is not paid to these other details. This is the foreman's and contractor's work. The men must be taught to use the right motions and the foreman must see to it that cars, wagons, barrows and other receptacles into which the dirt is to be cast, are not placed so close as to cramp the men in their work. Yet they must not be so far away as to cut down the amount of work the men are capable of doing.

This again calls attention to the heights of vehicles.

For instance, with a D-handle shovel a man working in average earth, who will throw into a vehicle not over 3 feet high, 1.4 cubic yards in an hour; will throw but 1.33 cubic yards into a vehicle 4 feet high; 1.2 cubic yards into a wagon 4 feet 6 inches high; with a vehicle 5 feet high about 1.1 cubic yards will be handled; 5 feet 6 inches high, not quite a cubic yard; and for a height of 6 feet, only 0.85 cubic yards. These are the details, the losing sight of which costs hundreds of dollars.

A contractor may show a profit on his jobs, but with these losses going on he is losing the money that would mean an extra profit.

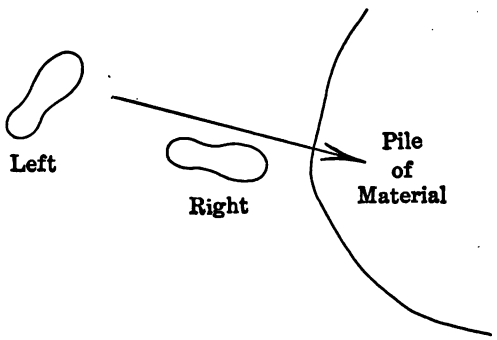

FIG. 1.—Position of feet for right-hand shoveler using a D-handle shovel. Arrow shows direction of shovel.

With the long-handled shovel, the correct method for a right hand man, is to grasp the shovel, with the left hand about six inches from the end of the handle. The right hand is placed on the shovel handle just above the straps. The right foot is placed close to the pile of dirt with the right side of the foot nearly parallel to the material. The left foot is placed 12 to 15 inches behind the right foot, the heel a little back of the right heel, forming an acute angle of about 30 degrees, as in Fig. 2.

The right hand is allowed to rest on the right leg just above the knee; the left hand against the body, at about the waist line or just below it. The shovel being against the dirt, the head and shoulders are inclined forward and at the

same time, as the arms are held rigid the knees are bent, giving the body that squatting motion. The entire body is thrust sideways, forcing the shovel into the material almost by the weight of the body and causing the arms and back to exert but little energy. The shovel is then lifted by straightening the knees and shoulders. With a slightly swinging motion the load is cast away. With the extra length of the handle this is done much more easily for a greater distance and height than with a D-handle shovel.

It can be seen at once that, in using the long-handled shovel, the man's position is more natural and that several decided motions that must be used with short handles are eliminated. This means more shovelfuls with less exertion. Couple this with the proper shape and size of shovel and the improvement in the man's work over that done by the untaught shoveler, with any short-handled shovel that may be given to him, is easily manifested.

In shoveling most materials a man should shovel from the bottom of the pile, pushing his shovel well under it, getting not only a good load, but assisting the material in the pile to run down so that the material is kept loosened. This insures larger loads. For fine sand and a few similar materials that are never compacted, this is not necessary and a worker can shovel from the side of the pile and do efficient work, unless it is necessary to clean up all the loosened material. Shoveling should never be done from the top of the pile, as the shovel is not likely to get a full load.

When shoveling from the bottom of the pile there should be a good base to slide the shovel on. The ground, if smooth, is a good base, but smooth rock or pavement is better. A board platform is good but one of sheet iron insures quicker work.

In cutting down a pile of dirt, rock, coal or any material, a short handled "D" shovel should be used. The "D" is held in one hand; the shovel grasped on the straps close to the blade with the other and held at arm's length from the body. Then, bending the back and digging the

tool into the material and drawing the shovel towards the body, a great mass of material can be cut down and pushed over the edge of a vehicle, embankment or ledge. By this means a mass equal to several times more than the shovel would hold is moved.

In starting to unload a flat car this motion of cutting down should be used, while the last dirt on the car should either be cast or pushed off with the shovel, or a small hand scraper.

Deep cars, especially hopper bottom ones, should not be unloaded by shovels if other methods can be used. For

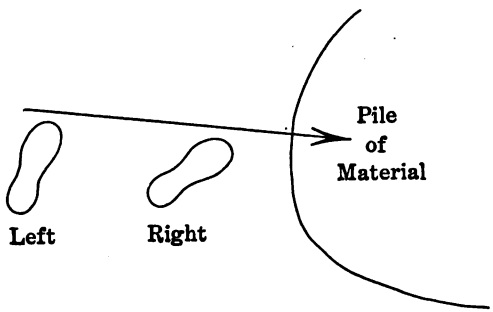

FIG. 2.—Position of feet for right-hand shoveler using long-handled shovel. Arrow shows direction of shovel.

most materials a cutting down scoop should be used. The author has never seen this style of shovel with a diamond-shaped point made except on a scoop and a spade. The spade, not being meant for shoveling, leaves only the scoop for this work. The diamond point greatly reduces the size of the scoop. As soon as the shoveler gets down to the bottom of the car with this scoop, he uses a shovel suitable to the material being handled. The tool should, by all means, have a long handle.

In unloading cars into wagons or trucks, the motions are shoveling, elevating and casting. In elevating material the most efficient work is done with a long-handled shovel. Never attempt to throw the material very far from the shoveler. In performing this act the body is drawn from

the stooping shoveling motion to an erect position and the material is thrown within a foot or two of the man's head. To throw it very far in front or behind the man cuts down his efficiency.

Men can cast farther and with greater ease to one side of them than in front or behind them. To cast any distance a man should take one step with one foot in the direction towards which he is to cast. This allows him to throw the material farther. Under no circumstances should a man be allowed to walk when shoveling. Generally more work can be done in rehandling the material than when the men are allowed to walk with small loads.

In spreading material with a shovel there are no certain and exact motions to be used. At times regular shoveling should be done; in other cases the cutting motion is used, and at times the material is pushed around with the shovel. In some cases it is only a question of leveling off a small amount of material.

In trimming, the shovel is grasped in the same general manner as in shoveling and the material is pushed ahead of the shoveler into piles. It is then shoveled into a vehicle or cast into low places.

Men should not walk while shoveling. This is a waste of time and money. Yet contractors and foremen frequently leave men do this. A shovel is not meant for transporting material; it is a tool for casting, elevating and similar uses. Beyond reasonable limits the material should be rehandled, or, better still, buckets, wheelbarrows, buggies, chutes, conveyors, carts, cars, wagons or other means of transporting and elevating should be used. Even for a small yardage, wheelbarrows should be employed. Men should not walk in shoveling; two steps are too many to take; one step should be the limit.

The exact limit of shovel work is difficult to set, as it depends upon the individual shoveler. One man can shovel dirt from a trench 10 feet deep as easily as another can from a six foot trench. The author once had a man in his employ who could throw earth from a sixteen foot trench

with a long-handled shovel, but it was not economical to have him do this. Also, some men can cast dirt 15 or 20 feet as easily as others can cast 10 or 12 feet. The limits must be set for an average workman, just as the load set for a shovel must be an average.

The Limits of Shoveling

For casting a horizontal distance and taking only one step with a long-handled shovel, 12 feet is the maximum. For a short-handled shovel, 10 feet.

For elevating and casting as in loading into a wagon or car, the maximum horizontal distance should be eight feet with a maximum height of six feet for a long-handled shovel. With a short-handled tool and a maximum height of six feet, the limit of horizontal distance should be five feet. The shoveler should never be allowed to let his shovel hit or rest upon the side of a vehicle as he is shoveling. This means a waste of time. The load should be thrown clear of the shovel. If the shovel becomes foul in the mud or cement, a small metal or wooden paddle should be used to clean it. Hitting the shovel against a rock does not clean it, but only injuries the tool.

For elevation only, as in shoveling from a trench, the maximum height for a long-handled shovel should be 8 feet. For a short-handled tool the limit should not exceed 6 feet. These are all maximum distances. To do the most economical work they should be reduced about twenty per cent.

To obtain the best results in shoveling, the individuality of the workman must be preserved. This is best done by tasks, but even when this is not always possible, the gangs can be made small, so that each man can be made to feel that his work is being watched. Working the men in large gangs defeats this purpose, makes the men lose interest in their work and encourages loafing.

Another extreme is working one man by himself. In very few instances can one man do efficient work. He is sure to set a slow pace. It is also against the nature of

most men to want to work by themselves. Two men working together will labor at a better pace. Most laborers have "buddies" with whom they travel and work and work better when they are together. It is nearly always possible to work two men together, but at times more are needed. If so, the number can be increased to four, six or eight.

If this is done, as in loading buckets, carts or cars, two men can come and go at the same time with their shovels. Thus in loading, if four men are shoveling, man No. 1 and man No. 3 can both be loading their shovels, while man No. 2 and man No. 4 are discharging the loads from their shovels. Thus two sets of men work together, each spurring the other on, and each set of men doing different work at the same time.

This might be termed "team shoveling." Teach it to men. They will become accustomed to it and like it, and keep it up without much attention from the foreman or contractor. Even with six, eight, ten or more men, this method can be followed:

With two men working together or men working in teams it becomes an easy matter to assign tasks and to keep a record of their work.

No matter how he is taught or made to shovel, a man cannot keep continuously at work. He must spell himself. Under ordinary conditions and with good workmen shoveling in average earth, a man spells himself about every 50 seconds. If he is shoveling to a great height (six to eight feet) or casting a long distance, he is compelled to rest about every half minute. If the conditions are favorable, or the proper incentive is held out, a man will not spell himself for a minute or even two. The author has had men go for two and a half minutes without spelling themselves. The rest lasts from three to six seconds. A rest longer than this is loafing.

Thus, the oftener a man stops to spell himself the greater is the lost time during a day. This alone can mean a large expenditure on a job and shows the necessity for

good conditions under which to shovel. Thus, without attention from the foreman, they will, of their own accord, cut out considerable lost time.

A step farther can be made in this direction. The size of a shoveling gang can be so gauged as to fill the vehicle in from one and a half to two and a half minutes, thus giving the men an incentive to work in pairs, without spelling themselves, until the load is finished. A decided rest is then allowed after which the work is speeded up, without rest for another period.

To illustrate: If a wagon can be loaded in two and a quarter minutes the men can be taught to spell themselves between loads, working without rest during the period of loading. If it takes eight minutes to load a wagon, four men working in the crew, the men will spell themselves for about four seconds, at least eight times. This means a loss of time for the crew on each load at the rate of one man for two to two and a half minutes. These are features of management beyond the control of the workmen, for the inclination to rest for a few seconds will come naturally. It thus becomes necessary for the foreman to watch these things and control them as far as possible.

One of the great troubles with shovels in the past, as used for nearly all purposes, has been in the method of selecting and buying them. To a great extent buyers have simply ordered shovels from their dealers, specifying as to length of handle and whether round or square points. If the shovels did not last as long as anticipated, a kick was made and possibly another make of shovels tried. In most cases contractors do not even know the name of the maker of their shovels.

How Shovels are Manufactured

To know how to buy shovels, a man should know something of their manufacture and selling. As the author has been a user of shovels and never a manufacturer, his manufacturing knowledge has been obtained only in order to purchase intelligently.

Shovels are made by stamping the blade out of a piece of sheet steel, or by forging or rolling an ingot into the proper shape and thickness, and forming it into the finished product.

Stamped shovels are cheaper and meant for light work, as moulder's shovels or those for handling snow or grain. Such shovels never have to stand severe service and can be made cheaper for this reason.

Shovels are made with straps to hold their handles. These straps are shaped and formed in several different ways. One is known as "socket strap," another as the "plain strap," a third as the "riveted strap," and the fourth as "hollow back" shovels.

The socket strap has a socket at the base of the handle, with straps extending up the handle for about a foot. This is the strongest method of fastening the handle to the shovel. Plain straps are without the socket and the straps extend up the handle. As the name denotes, riveted straps are those riveted onto the blades. At times these straps are reinforced with another piece of steel. Hollow back shovels have but a single strap curved into a round tube through which the handle is inserted, allowing it to slip down against the back of the blade.

The hollow back and light weight shovels previously mentioned as being stamped out of a piece of sheet steel, are first stamped and then the straps are welded onto the blades. This makes a plain strap shovel. The hollow back shovel either has the strap welded onto it or it is stamped out with the blade and then shaped into a tube to receive the handle.

The riveted strap is also riveted onto the shovel after the blade is shaped. This may be done either with a stamped, rolled or forged shovel.

The ingots for a forged or rolled shovel are manufactured in two ways. First, by means of crucibles. This means that the metal is heated in crucible pots and poured into ingots. This is the most expensive method and produces the best results. Shovels so made are always marked

"crucible steel," unless the manufacturer makes only this grade.

The second method of casting ingots is from open hearth furnaces which does not produce as good a grade of steel. Such shovels are marked "solid cast steel." Shovels that are stamped out are generally marked "solid steel."

The ingots are cast in such shape as to make the various sizes and shapes of shovels and also the straps. In forging or rolling and shaping them, it is possible to make the blade of varying gauge, the point or cutting edge being lighter. The back edge and part around the base of the socket are of heavier gauge. This is important, as a great strain comes on the shovel around the base of the socket, and a poorly made shovel is very likely to break at this place. This is especially so if the workman is allowed to place his foot upon the blade in shoveling.

The cutting edge of the blade should be of the best material, for as it becomes worn the carrying capacity of the shovel is cut down, and the shovel becomes worthless.

The best grades of crucible steel for shovels often have certain alloys combined with the steel. These alloys add to the cost, but they drive out of the steel certain impurities and gases, making the metal harder and tougher. The two most used alloys are nickel and chrome. Steel made with these alloys gives better wearing results than the ordinary carbon steel. As a further means of securing greater efficiency from the steel, the shovel, after being formed, should be heat treated. This heating tempers the metal, making it tough and strong. This is another means of preventing the cutting edge from wearing down and making the shovel smaller.

Shovels are either painted black or polished. Some tools have the upper half of the blade painted and the other half polished. An extra price is generally paid for the polished goods. For contractors the black shovel is just as good as the polished. Some demand the polished goods, believing that they are getting a better shovel,

as they believe the paint is put on to cover defects. Any defect in a piece of steel or in the manufacture of the shovel that would not entirely condemn it for selling purposes can be hidden by polishing as readily as with paint. Consequently the polishing means nothing except to make the shovel bright and to grind away a thin coating of the steel.

Most manufacturers grade their shovels. An honest manufacturer replaces his tools that are not satisfactory, so he does not use paint, nor polish them to hide imperfections. A shovel showing flaws, that is, not trimmed properly, or one that is not up to the manufacturer's standard set for a certain grade, is placed in a lower grade. A manufacturer who makes only one grade (and only a few do that) must scrap a shovel that cannot be placed on the market. A brand of shovel carrying the manufacturer's name must come up to his standard or else he cannot afford to place his name upon it.

Some manufacturers do not grade their shovels according to defects, flaws, etc., for all of such may be scrapped to be heated and made over again. These firms do their grading according to the character of the steel used. Thus, the first grade may be crucible steel, the second and third grades open hearth or cast steel, and the fourth grade sheet or solid steel.

No tool is stronger than its weakest part. This is true as to the metal of the tool, and with a shovel it applies especially to the handle. A shovel with a good blade, but with a cheap handle, is a poor investment. The wood in the handle must be of a good grade, well seasoned, carefully selected. The handle must be skillfully made. The handle should outlast the blade, for it is seldom possible on construction work to have a blacksmith put a new handle on an old blade.

Dimensions of Shovels

The dimensions of a shovel are those pertaining to the blade. The length is measured along the center line drawn from the center of the cutting edge to the center of

the top strap at the top or rear of the blade. This measurement is the straight airline and not along the metal. The width is that straight across the blade at the cutting edge. In speaking of the length of handle, the shovel is laid on the ground face down and the length "over all" is from the point or cutting edge to the tip of handle. The length from the top of blade gives the net length of handle.

An important consideration is the lift of the shovel. The lift is considered in two ways. Some manufacturers lay the shovel on its back with the blade pointing up. The lift is then measured from the ground to the point of blade or the center of the cutting edge. This lift can be changed to suit the user, varying as it does from a few inches to 8 or 10 inches, except in such tools as are made from set dies. In these the dies set the lifts and they are known as "regular lifts," "half lifts" and "low lifts."

Other manufacturers measure the lift by placing the back of the blade on the ground and measuring from the tip of the handle (for a long-handled tool) to the ground. For a D-handle, the measurement is made from the back of the "D" to the ground. This lift can also be changed except on the shovels made with dies. The author believes this last method of considering the lift is to be preferred, for it is this measurement that gives the user the idea of what lift he must make with his arm and back in handling a shovel.

A simple test of the strength of a shovel is to clamp the blade of a shovel to a table or bench, with the handle sticking up. To this end a pressure can be applied with a machine or weights can be tied on it. Any well made shovel should, without developing weakness, stand a pressure of about 200 pounds.

How Shovels are Sold

For domestic trade, most manufacturers tie their shovels in half-dozen lots, although they can be purchased wrapped in burlap, crated or boxed. For export trade, the bundles or crates contain a dozen shovels.

Shovels are sold by manufacturers either direct to the consumer or through agents or hardware dealers. Manufacturers selling direct always sell under their own brands. Those selling through jobbers may sell under their own brands, and may also brand the shovels under the local jobber's or dealer's private brand.

No matter how the shovel reaches the consumer, a manufacturer selling only under his own brand is apt to give better satisfaction to the consumer, for his name and brand are on the shovel and he feels responsible.

On the other hand, a shovel offered for sale under a dealer's brand may not equal in grade those sold under the manufacturer's brand. Then, too, the responsibility is divided. The customer will not know who the manufacturer is, so he must rely for satisfaction upon the dealer. The latter is apt to place the fault upon the manufacturer, and say he will take the matter up with the factory. If the manufacturer is producing a tool under the specifications of the dealer, his responsibility ceases when the dealer accepts them. The buyer is thus likely to fare badly. The author's preference has always been to purchase a shovel bearing the manufacturer's name and brand, even if such a tool costs a little more.

Manufacturers are to blame for not branding their shovels better. Fancy colored labels soon wear off. Most manufacturers stencil their name and the grade of shovel on the top strap, but this is in small letters and can also be worn smooth. The name and brand should be stenciled on the strap and also burnt on the handle. The place on a D-handle shovel is on the flat part of the "D." On a long-handled shovel is should be about 18 inches from the end of the handle. Thus, no matter how long a shovel is used the name of the manufacturer and the brand can always be read. This would be a protection to the manufacturer and a service of great satisfaction to the user, who could duplicate a shovel that proved well made and economical in its use.

Naturally a user of shovels likes to get them from some

nearby dealer. He has established credit there and can get a half dozen or a dozen shovels quickly. He is not willing to wait several weeks. If the dealer does not handle the particular brand of shovels desired, he will stock up on that brand if he feels that the customer is a desirable one and will continue to trade with him.

Shovels are listed as to prices and there is generally a discount from the list. Manufacturers sell to those with established credit on a basis of net cash at 60 days and two per cent discount for cash within 10 days from date of invoice. In buying, it is necessary to state the style, size, kind of handle, grade or brand, and whether black painted or polished shovels are desired. Black shovels are shipped unless polished ones are specified.

The Abuse of Shovels

In closing, a few words may be written regarding the abuse of shovels. They are not meant to be used as hammers to knock out tail gates and open car doors. Nor are they built for levers to be used in dumping cars or prying out rocks. Nor are shovels meant to cut roots and small stumps. Shovel handles are easily broken when used as a chuck for a wagon or cart when being dumped, and it is not advisable to use them in swinging the boom of derricks, in place of a tag line. The wooden "D" is not strong enough to tamp dirt or stone. The "D," once cracked or broken, makes the shovel useless, unless an iron "D" is used. Shovels are meant for use as shovels only and no matter how well made they are, they will not stand abuse.

Author's Note.—The study of the use of shovels is given in this chapter in order to show how time and motion studies can be made to aid in systematizing shoveling, and to illustrate how all construction work is susceptible to analyzation and can be placed on a systematic basis.

CHAPTER VII

APPLICATION OF MODERN MANAGEMENT

The various aspects of modern management have been discussed as well as the underlying principles and those auxiliary details that assist in devising a modern system of management. In this chapter those principles set forth in Chapter III, will be discussed showing how construction can be carried on and cheapened by following these basic principles.

Planning General Methods

Planning the general methods to be used is the work of the contractor and his general manager. The first essential is to have knowledge of the job. This is obtained by visiting the site of the work, making a close study of the plans, specifications and contract, and obtaining the quantities of work to be done.

The quantities of each class of work to be done for some kinds of jobs may, in some cases, be furnished by the engineer. This is true of railroads, but the owner does not guarantee the accuracy of such quantities. They are approximate only. In other kinds of construction the contractor must estimate such quantities from the plans, and is himself responsible. If sub-contractors are to use quantities, the latter are generally compelled to make their own estimates. This is the case in the erection of buildings. This class of work is known as quantity surveying. It is always of importance, but is not so vital on a contract with unit prices as when a lump sum bid is made.

The owner should be as much interested in the correctness of the estimates of quantities of work to be done

as is the contractor. It should, therefore, be his business to have the quantity surveying done by a reputable firm and have prices based on such a survey. This should be the practice and it is pleasing to note that some companies are taking up this work of quantity surveying. Contractors should do everything in their power to introduce this method. If owners will not pay for this work, then contractors should do so and include it in their bid prices.

It is upon these quantities that the estimate of cost must be made and the general plans of the methods to be followed mapped out.

Most contractors think the first work to be done in bidding upon a job is to make up the estimate of cost. This is erroneous. An accurate and fair estimate of cost can be based only upon the general methods to be used and the kind of plant to be employed. Even a man who may never touch pencil to paper in order to analyze his cost and make up his estimates, or one who states that he bases his estimates entirely upon his long experience in construction, and decides upon his methods and plant after he secures a job, will find himself following the idea of methods and plant first, and deciding upon his costs afterwards.

This is a typical conversation between two partners or a contractor and his general manager. "Jim," asked one, "what can we do that excavation for?"

"I would say 45 cents," was the reply.

"Well, I bet we can do it for 40 cents and make a good profit," argued the other. "Look at this plan. We can put that largest steam shovel of ours in here, lay two sets of tracks to it and carry the spoil to these two dumps, using three trains, having one under the shovel all the time, and fairly make her hum. You know we have excavated nearly 50,000 yards a month with her with two trains, and with three we will go up to 60,000 and some months 65,000.

"Now 5,000 extra yards moved in a month means $2,000 —enough to pay for the extra train and reduce the cost of

all the excavation at least 20 per cent. Then I propose that we make all the waste they will allow us to make from the top of the cut with scrapers and, on a short haul of a hundred feet or less we can do it at a good profit for 30 cents. They have got 40,000 yards of waste marked on the plan and that means over $5,000 profit at 40 cents a yard. I think we can further reduce the cost of the steam shovel work by using larger cars. You know we have wanted to try out these large cars and this is the job to do it on. I tell you we can bid less than 40 cents and make a big profit on this job, but I think 40 cents will take the job. Don't you?"

"I believe you are right," replied the other partner. "Then, too, the extra train and the scrapers will cut down the time, so we can make a quicker finish, and that means less overhead charge."

So the conversation continued, discussing plans and methods, the type and amount of plant to use, time schedules and estimates of cost. If the prices and plans were to be based upon such details why not write them down and sketch them on paper for use if the job is secured. Then it is only one step more to make up such plans first in order to estimate the costs and set the bidding prices. This gives an exact basis of figuring costs and also of carrying on the job, which can be improved as the work is developed, leaving nothing for guessing or for a chance decision.

Some of the ablest contractors in the country are coming to this view and are following along the general lines laid down by the author. Thus, under the heading of planning general methods we have for consideration (four) subheadings. (*a*) General Plans; (*b*) Plant Selection; (*c*) Time Schedule; (*d*) Estimates of Cost, in their natural sequence.

General Plans

This work must start with a study of the owner's plans and specifications and from an inspection of the ground. Copious notes must be made. A list of all materials with

probable amounts must be made so as to obtain quotations and deliveries on them.

Then the actual planning of the work can be begun, designating the general methods to be used. These features will be noted as they are worked out from the owner's plans and the notes taken, accompanying the notes with sketches where necessary. These features, however, must be done in connection with plant selection.

Plant Selection

This is the most important part of the general planning. The detailed methods will depend upon the kind and amount of plant to be used, as will the progress to be made upon the job. The selection of the plant will govern, to a great extent, the estimated cost of the various units of work. To select the plant properly one must possess adequate plant knowledge and must keep in mind the necessity for substituting machinery for hand methods, wherever possible, yet not have an excessive amount of plant. These features of plant selection have been covered in Chapter V.

All the general items and amount of plant to be used should be set down in a schedule, showing the different machines and upon what part of the job they are to be employed. This must include forms for concrete and temporary structures for other uses, so that all of these things will be known in advance and included in the estimate of cost. It will be from the notes and sketches here made that the plant layout will be designed. From the list of plant thus made it will also be possible to decide what new machinery will have to be purchased, so that quotations and dates of delivery can be obtained. All of these things will mean that a job will run smoother.

Time Schedule

The plant selected, the general plans made and the kinds and quantities of work to be done listed, it is pos-

sible to arrange the time schedule. If the time limit for the job is set by the owner, the schedule is made up by the contractor so that he may know the amount of work that must be done each week, month or year. If the contractor is to set the time limit, he must arrange the schedule to see how soon the job can be completed, and, allowing a fair margin of time for a finish, name the number of working days or set the date for completion. An exact schedule is of great assistance in this matter.

If the contract names a bonus for quick completion and a forfeit for delays, even more importance is to be attached to the time schedule. It is surprising when this work is done with knowledge and care, how quickly some jobs can be completed. Some years ago the author was bidding on an important job upon which the owner asked for a 14 month finish. Taking into consideration the items and quantities of work, the plant to be used and the general plans, the author made up a time schedule to finish the job in 7½ months. Adding 6 weeks to this to be safe, he suggested to the president of the owning company to make the job a 9-month's finish on a bonus and forfeit basis. This was done and the job was finished in less than 9 months and a bonus earned. Such an offer could not have been made with safety without careful planning and consideration.

Time schedules, graphic progress charts and diagrams should be made. These will show the various amounts of work to be done and divide the work so as to show what plant will work on the various divisions. All available information should be placed on such diagrams and charts. These are not used to record the progress made but are kept as standards to work to throughout the life of the job.

When the work is started, additional charts, diagrams or profiles are made, upon which the actual progress is recorded. Comparisons are made of these with the originals or standards to see if the time schedule is being carried out properly. If it is not, arrangements can be

made to increase the rate of progress, notation being made on the originals to show wherein they were wrong so that this mistake is not likely to be repeated on another job.

The time schedule should likewise show when each item of plant is to be installed, so that arrangements can be made to have it in ample time. The same thing holds true for construction materials. Otherwise delays may occur that will prove expensive.

The time schedule and progress charts can be made up in two ways. One is a diagram to show by a curve the amount of work done and the time consumed. This method is not applicable to all kinds of work. The second method is to show by a chart, profile or plan, the work done, using figures and lines or different colors if these will answer the purpose. Duplicates of these can be made for use by blue printing.

In some cases besides the general progress chart there can be made up a summary progress chart showing many features in a concise form and giving the summaries of all work done. This will be a short history of the work. One such chart for each section. If the job is small, one for the entire job is sufficient. This summary can show the percent of work done, the date, the amount finished, the units of work done, the estimated cost, the actual costs and other features. Thus a busy contractor or general manager can tell the important features of the job at a glance. The time schedule and progress charts will be used by the routing departments when the job is obtained.

Estimates of Cost

With the foregoing information in hand, estimates can be made of the costs of the work. This subject has been discussed in The Economics of Contracting Vols. I and II, so it will not be taken up here. If the job is secured the estimated costs should be used as the standard for comparison with the actual costs.

The contract having been obtained, the work already done becomes the basis for planning and handling the job. All of these things should be revised at once so that improvements can be made wherever possible. This brings up for consideration

Designing and Engineering

The work already described is preliminary to bidding, and, besides being useful in presenting a bid, becomes of value as soon as the job is obtained. The work to be described follows immediately upon the award of the contract. It can be deferred and money made on a job, but the best type of management demands that this work be done in whole or in part before a machine is placed on the job or a hand turned to the work. It is termed engineering, for this is the broad meaning of engineering given to the world by the late A. M. Wellington, when he said: "An engineer is one who can do with one dollar what another may do after a fashion with two."

In Wellington's day the world did not know the term "scientific management." Little was known about modern efficiency engineering, but the greatest American engineer of his day, the man who left the world richer for his writings in *Engineering News* and his classical books, anticipated the work of the future in giving utterance to this wonderful definition. It is not only the basis of scientific management, but of all the work of engineers and contractors.

It means that one who may not possess an engineer's degree may, by his own studies and training in life, become a competent engineer—even a *great* engineer. Many of those men who built the great engineering structures during the first half of the last century were men of this stamp. There were few colleges in those days that taught engineering or gave such degrees, and these early engineers, with a fair knowledge of mathematics, were pioneers in giving the world engineering formulæ and the modern prac-

tices of civil, mining and mechanical engineering. Such men were Peter Cooper, Roebling, Latrobe, the first Trautwine and many others. Even today, when engineering colleges are numerous, the world honors men of this stamp, —men who have educated themselves in engineering and established themselves as great engineers, such men as Edison, Cooper, Mulholland and Whinery.

For this work of designing and engineering, therefore, an engineer with a college degree is not absolutely essential. One trained in construction and in the management of machines and men can do the work. If he also possesses an engineering education it may make his work better and he will probably be more efficient.

Under the modern system of management it is this department of designing and engineering that will be in charge of all the work from start to finish. The entire work will be planned in every detail by it and the department must see that these plans are carried out. When it is not possible to follow the plans the reason why must be found and recorded in order to plan better in the future. The contractor himself or his general manager may be at the head of this department. If so, he must carry out his plans to the letter, instead of deciding matters off-hand, as the work is being done.

a) Making Charts and Plans

The general outline of plans was made as estimates were being made upon the job. These are now worked up in detail. The character of the work will govern the extent of the plans needed. For excavation only the plans will be few and simple. For a concrete structure, such as a bridge or building, there must be a large number of plans. For such a structure as a dry dock or one that embraces a number of difficult classes of work, a set of plans for each class of work may be necessary.

The entire job may be covered by these plans or it may be divided into sections or small divisions and plans

made for each one. The general methods to be followed should be shown on the plans as well as the work to be done. It will often be possible to take copies of the owner's plans and adapt them to the use of the contractor. In order to decide upon the forces to be used on each part of the job, the probable amounts of work should be placed on these plans. The necessary forces can then be estimated and noted on the plans. Thus the kind and amount of work to be done, the location of the work, and the forces needed are all on a single plan, and any intelligent foreman can take such a plan, start that part of the work and carry it on with the minimum of supervision.

The charts to be made will consist of those to show the progress to be made and others to record the actual progress made. Other charts and diagrams to record special features may be needed as the job progresses. For instance, in studying the service of special machines, or in making comparisons of costs with certain standards or the waste of some materials, results can frequently be shown by charts or diagrams.

Many contractors may consider these things useless, for they have done without them in the past. They are, nevertheless, the basis of modern management and are necessary if nothing is to be left to chance. Fifty to one hundred years ago all business was carried on without the aid of the telegraph and telephone, but today few would care to give up these modern conveniences. So, those who have learned to apply modern methods would not do without them.

(6) Designing Plant Layouts

The various plans having been made, the plant layouts can be mapped out and placed on these plans. These plant layouts will be made from the list of plant selected when bids were made upon the job, with the necessary appurtenances to make the plant complete. It may be necessary to make surveys so as to plan the layouts in a

systematic manner, having distances given so that each machine will fit in its exact place and thus reduce the service to the minimum. It is evident that, if materials have to be moved excessive distances, as is frequently the case on many jobs, the cost is bound to be greater than it should be. This is a common failing in placing concrete mixers which causes the raw materials to be handled at a greater cost than is necessary. The same thing happens with other machines.

Another advantage gained in drawing plant layouts is that some device or machine may suggest itself to be used in place of hand methods. This may mean many dollars saved on a job. It also means that ground is not wasted, nor is one machine placed to interfere with another. To do this work properly, the dimensions of all machines must be shown on the plans and the range of the machine must be given.

The storage yards or spaces for materials must likewise be laid off and marked on the plans. This alone may mean many dollars for the contractor. A common mistake made in this connection is in storing concrete materials. The bulk of a thousand cubic yards of concrete will be about 1,250 barrels of cement, equal in bulk to 185 cubic yards of cement, about 450 cubic yards of sand and about 925 cubic yards of crushed stone or other coarse aggregate. The logical method is to store the stone, the largest bulk, close to the mixer, the sand next and the concrete the farthest away. In most cases, the cement shed is next to the mixer, the sand pile next and the stone farthest away. Paper planning will prevent this in most cases.

Certain kinds of plants must be moved along with the work from day to day, week to week, or month to month. If this is the case, the plant layout should be given at the start and then the various moves for doing given parts of the work should be shown. In other cases—as a concrete mixer on a concrete road or a steam shovel in a pit—the plant is moved continually over the work. Such moves can also be shown on the plans, giving, at the same time,

the approximate amount of work to be done from each set-up, and showing the path of the machine.

It is just as important for a contractor to plan the layout of his plant as it is to plan the erection of a building. There have been many houses built without plans; they show it in their cost and design.

(c) Designing Rigging and Structures

There are many devices such as derricks, concrete hoists and chutes, cableways and other rigging that contractors have to erect on different jobs. Sometimes these must be erected several times on the same job. Generally these things are shipped to the job and a foreman is allowed to erect them. A large stiff-leg derrick may be placed and rigged ready for work by one foreman in several hours. He may take it down without a mishap in less time. Another foreman may take the greater part of two days to erect the same derrick and in taking it down may break one of the stiff legs, bend the irons on it and break the gudgeon pin in the top of the mast, using a day in getting the derrick in shape to haul it to another site.

Such things should not happen. The rigging of such machines should be done, not according to the meagre knowledge of the man who is given the task, but according to the best practice of the most adept man in the organization. This can be done only by having a standard plan with detailed instructions showing each step in the task. In like manner, an expert will put up a large tent in an hour or two, while a tyro is likely to punch a number of holes in it, tear it at the bottom, and use several hours in so erecting it that it will blow down during the first high wind. This can be prevented by following instructions furnished by an expert tent raiser.

Not only will such procedure save money and time but the chance of accident and injury to men is reduced.

There are also numerous buildings that a contractor must erect for his own use—cement houses, shops, tempo-

rary offices, buildings over plant, material bins, and buildings for the men. For all of these there should be standard plans and bills of materials, with instructions as to how to erect them in the most economical manner. This means the saving of money both in materials and labor. If buildings are built in sections, diagrams and instructions should be drawn up so that this work will be done expeditiously.

(4) Quantities of Work and Material Lists

Attention has already been called to the need of listing all quantities of work to be done to prepare an estimate for the bid. These same lists can be used, after being checked up and revised, for carrying on the work. They can be placed on the plans and can also be given in the form of written instructions to superintendents and foremen.

Material lists must also be made. These are sometimes furnished by the engineer for the owner. Such lists, when so furnished, should be dated and filed as a permanent record of the job. Copies of them should be made for use on the work. Then, too, from such lists other lists should be made up to use in purchasing the materials. This is necessary if judicious buying is to be done. Take for instance a job on which several timber structures are to be built and heavy timbers must be bought. The material lists, as drawn up for each structure, may make the prices run high; if they are re-grouped and placed with different mills or dealers, a large saving may be effected. So it is with many other lines of materials. By re-grouping the materials it is also possible to get better deliveries, especially for those materials that may be needed in the early stages of the job.

(5) *Routing Work*

To have work done economically it must be routed; the sequence of the details and the various classes of work,

the handling of the materials, the distribution of the work and the number and size of the gangs needed must be considered. This routing can be done by the engineering department, by a separate department, or the two departments can be under the same head.

2. Sequence of Work

The task here is to eliminate all wasteful motions and repetitions of work, and so plan the details that one man or one set of men will not interfere with others. Every detail must be considered. Thus, in loosening earth with picks, the pickers must not interfere with the shovelers, and the loosening must be done prior to the shoveling. In charging a concrete mixer it must be decided which raw material will go in first, which second, etc.

In fact, every detail of the various classes of work must be considered and the sequence of each planned and mapped out. All of this information should be written down, either in the form of diagrams or instructions so that foremen and intelligent workmen can read and understand them.

In addition, the sequence of the various classes of work must be planned. For example, first comes excavation for a concrete structure, then shoring to hold the earth, and then the concrete construction. It is by following the sequence of work in this manner that sewer construction can be done at the lowest cost and in the most systematic manner. For instance, first the excavation must be done, then the pumping and shoring, the trimming of the bottom, the placing of the sewer, the back filling and the moving ahead of the plant. Each item of this work may have to be planned in detail and the sequence of the various items set down. Thus it may be possible on many sewers to complete a certain length each day. As it is with sewers, so it will be with other structures; all of these principles are applicable to any kinds of construction.

(B) Routing the Handling of Materials

This work begins with the deliveries of all materials. It covers their storage and their rehandling to machines and in place. It likewise covers the handling of materials to be prepared for use, such as the framing of timber, the cutting and fitting of steam or water pipe and similar classes of work. This work should be so planned as to handle all materials the minimum number of times, to prevent the changing of storage piles, and not to have materials come upon the job before they are needed. As now practised by most contractors, some of this work is done well, but on most jobs there are glaring defects which can be prevented by proper forethought. Most of this planning must be done in connection with the distribution of work.

(C) Distribution of Work

This covers not only the work of handling and placing materials, but also other work in which materials may not be used, such as excavation. This distribution means to have high priced men do only such work as may require their skill. Carpenters should frame timbers and not handle or carry them. This work should be done by unskilled laborers. The high salaried man will frame more thousand feet of timber a day, while the laborers will handle as many thousand feet of timber as the high priced man and at a less cost.

To illustrate: A contractor paying bridge carpenters $3.50 per day had two of them taking ties from a pile, sawing them to proper lengths, dapping the ties to fit over the stringer, and placing them in a new pile. The author was called upon to systematize this contractor's work. He at once added two laborers to this crew, and had a template made to mark off the ties, for length and the dap, instead of using a rule and square. The laborers served two gangs of two carpenters each. Their pay was $2.00 per day. Thus $4.00 per day in labor served carpenters receiving

$14.00 per day. The laborers took the ties and placed them right side up on a long bench made of timbers, each tie being so spaced by marks on the timbers that working on one did not interfere with the others. Six or eight ties were kept in place at all times for the carpenters. The carpenters marked off the ties, sawed them and adzed them; the laborers removed them as they were finished. Thus neither set of men interfered with the other and each did the work for which they were suited.

By the old method the carpenters handled and framed sixty ties a day, containing 3,840 feet B. M. This was at a cost of 11⅔ cents per tie, or $1.82 per thousand feet B. M. for framing and handling. By the improved method, one hundred and twenty ties were framed in a day by two carpenters. This meant a cost of 5.83 cents per tie for framing, to which was added 1.67 cents per tie for handling, or a total cost of 7.5 cents. The cost per thousand feet B. M. by the new method was 91 cents for framing and 26 cents for handling, a total cost of $1.17. This meant a nice additional profit to the contractor.

The carpenters' work was easier and the laborers did not have to work very hard, but this made an economical size of gang for this and other framing work.

The same principle is applicable to machines and teams. It is common to see three or four men shoveling into a wagon, taking from eight to ten minutes to load, when from eight to ten men should load a wagon in three or four minutes or less. Thus the lost team time on three or four wagons amounts to quite a large sum in a day. The work should be so planned as to keep teams moving as much as possible. That is why loading devices, even for a limited amount of material, are economical. A small steam shovel may not work half the day, yet the cost of excavation may be small as compared to hand work, owing to the fact that the teams do their maximum amount of work. It can be seen that if the machine can also be kept employed the entire day, the cost will be further reduced. This calls attention to the service of machines.

A man or two extra to serve a machine may mean increasing the output enough to reduce the unit cost of the work considerably.

(c) Number and Size of Gangs

The number of the gangs to be worked, as previously explained, will be decided upon in planning the work, in making the plant layouts and in listing the quantities of work to be done. These factors will control, to some extent, the size of the gang, but other considerations will also affect these things. The job may call for a hundred men to use shovels, but this does not mean that all of these men will work in one gang. They can be divided into ten gangs, if necessary, each crew being composed of two to twenty men.

The size of the gang must depend on the service to be rendered to a machine or some particular section of the job, and the best unit by which to measure the work to be done. If cars of coal are to be unloaded, ten men can be placed in a car, but two men are likely to do more efficient work than ten will do in proportion. With five cars to be unloaded, two men to a car will unload the coal quicker and cheaper than working ten men to a car and changing them from one car to another.

In such cases the two men are paid for the extra work they do. Some advocate working one man by himself as much as possible, but the preference should be for two men, except in a few cases. Two men are not so likely to loaf as much as they would if working singly, and each man sets a pace for the other. For some work the size of the gang must be four, six, eight, ten or more, but it is well to keep the number as low as possible. This subject leads to the consideration of rewarding the men.

There must be men enough on the job to finish it within the contract time, and in planning the gangs the cost of superintendence must be considered. There must be supervision enough to prevent men doing work the wrong

way, and skimping it. Yet the cost of supervision must not be excessive. One advantage gained from modern management is to reduce this item of cost.

Instructions for Workmen

Such instructions should be, as much as possible, in writing or printed and supplemented by sketches, drawings and photographs. Every known expedient to assist in this work of instructing men should be employed. At times, and under some conditions, the instructions must be oral.

Instructions for Mechanics

Mechanics and various kinds of artisans are among the higher classes of workmen employed by the contractor. As they are paid high wages, any misdirected or useless work done by them means a decided loss to contractors. Their work must be controlled at all times and a constant check kept on it. Most of these men can read and write, so that all instructions to them should be either printed or written. All general instructions and those pertaining to general methods, cost keeping and other features that will vary but little on different jobs, can be printed and cuts made either from drawings or photographs to illustrate them. Such instructions can be made up under different headings and put into book form. The various headings, such as Excavation, Concrete, Brick, Stone Masonry, Paving, Tunneling, and numerous others can be employed to suit the classes of work a contractor may do. Each can be made into a separate pamphlet or all can be grouped together in one book.

In this way all general methods of doing work can be described, and some details can even be given. Drawings and photographs should be used to make the instructions plainer as some men who are poor readers can learn much from the drawings and photographs. Another advantage gained from such instructions is the standardizing of all

methods to prevent waste of money in estimating and in carrying on operations. In many cases, contractors have one man or one set of men make up their estimates for bidding. Then, if the job is secured, another set of men handle the construction. Thus more expensive methods may be used than those figured upon, resulting in a decided loss. A profit may be made on the job but that is not the question. The feature that the contractor should consider is whether *all possible profit* is secured.

Then, too, jobs are sometimes lost in bidding by the estimates being higher than the actual cost of doing the work by the methods used by the contractors' managers in the field. The field forces and the estimating department must be in close touch. Modern management and close competition demand this and the best methods of keeping the two in accord is by standardizing every feature of construction that will admit of setting and maintaining a standard.

There are many details of construction that will vary on different jobs. For many of these special instructions must be issued on cards or in the form of bulletins. Those on cards can be accompanied by sketches or drawings. Bills of materials can also be shown on the cards as well as other data that will assist the mechanics. A sketch is a rough drawing made either in pencil or ink, not to scale, but all measurements are placed upon it for the mechanics to read. This sketch may be a side or end view showing some detail only, it may show a complete unit of the work, or possibly an isometric view will give a general idea only. All sketches should show measurements.

By means of a sketch and written instructions a card will show a stonecutter how to cut and dress a piece of stone of a given size or a number of stones of one size or varying sizes, if of the same shape. The number of stones of each size can be listed on the card. A card can be used to instruct a carpenter how to cut up and frame a piece of timber for a structure or form. All of these things should be made in the office. The sketches and instructions will show how

to frame timbers economically to suit the sizes ordered. Without such instructions much timber may be wasted. This is especially true of form work.

Instruction cards also serve another purpose. As a mechanic works from them he can list, in space provided, the number of pieces produced in a day, or he can give the total time used in carrying out the instructions, if more than a day is used. Thus a cost record that may prove invaluable is obtained. Then, too, the speed and character of work done by different mechanics can be gauged and it becomes possible to devise means of making all men do their work up to the same standard and with about the same speed.

All such cards and records should be filed under a good system so that they can be found easily for they may be needed for estimating or to save labor in getting up new cards for other jobs. Many of them may only have to be copied for use on another job. For this purpose, cards can be made up in series showing various steps in doing certain kinds of work. Thus for timber, one series of cards may show how the framing is done; another set will show how to assemble the different pieces; a third will show how to take down the various parts and move them, if this is necessary. Such cards may mean a little extra cost in office work, but the saving on the job will offset this many times.

Instructions for Common Laborers

For use by uneducated laborers, written or printed instructions are valueless. Such men must be taught by a practical demonstration. It is possible, however, to have most of these instructions printed or written so that superintendents and foremen can understand them and, after becoming familiar with the details, teach the laborers the essentials. Some intelligent workmen who can read and who have influence with their fellows can assist in such work. Such instructions must be given to the ma-

jority of the men orally. Photographs or cuts are a decided help in this as they show the right and the wrong positions and movements of a man's body. The tools used in working may be pictured, too. The position of a man's feet at his work is always of importance. This can be shown to both the foremen and men by diagrams. These features, as they apply to shoveling and the use of shovels for many purposes have been covered in the previous chapter. As it is with shovels, so it is with all other tools and machines.

Men must be so managed that they will be continuously at work during the regular working hours. The ordinary man in the employ of a contractor works about ten hours. On public works this is reduced by law to eight hours. To consider this question we will take the man on public work laboring 480 minutes a day. When he starts to work in the morning he must find his tools and obtain instructions from his foreman, who is a busy man at the starting hour trying to get a large number of men to work promptly. The workmen may be delayed in waiting for teams or in waiting to be served. There are many reasons why every man does not start to work promptly on the stroke of the clock. About fifteen minutes is generally wasted in getting started. In some cases the time so wasted may be less, but in many cases it is more. Foreigners are very apt to waste time purposely in beginning work.

At noon, men are on the alert for the time to stop to eat. This causes a waste of time—seldom less than five minutes. In starting work again, time is wasted (about ten minutes on the average) and at quitting time about ten minutes are lost. Thus during the day an average of forty minutes is lost starting and stopping work and this amounts to one-twelfth of the man's working time. With other wastes of time during the day it is safe to say that at least an hour, or one-eighth of the man's time, is lost. If he is excavating earth and this time could be conserved, each man would excavate another cubic yard or more.

Then, too, in order to keep men busy, they must be driven. An unwilling man seldoms puts forth his best

efforts. For these reasons on most construction, men should be worked in small gangs so that foreman can give them the proper supervision and keep them busy. This adds to the cost of the work. In earth moving alone the writer has frequently seen the foreman cost run from 10 to 25 per cent of the total.

Little is being done by the majority of contractors to better these conditions, yet the remedy lies at their doors. Men can be paid on such a basis that the more work they do the more pay they receive. Thus every man, especially if he is guaranteed an ordinary day's wage, will put forth extra efforts to earn an increased sum.

The Basis For Rewarding Workmen

Every contractor has a basis of rewarding workmen. The usual one is to pay them some hourly, daily, weekly or monthly wage. In some respects this is fair, especially to the workmen, but the employer may suffer as some men will do no more than they must in order to hold their jobs. To compel men to put forth their best efforts, both mental and physical, there must be a guarantee of the ordinary wage for the regular work with incentive for extra work. There are, today, a number of methods for this, but the one best suited, in the author's opinion, to construction work is that known as the "Task and Bonus System."*

Usually the rewarding of the men comes under the timekeeper, the paymaster and the superintendent. One or more men may occupy these positions. These men make up a department that can look after this work and the outside cost keeping. Their work is most important to any organization and their ability to carry out contracts is based upon the workmen and how they are handled.

Tasks and Bonuses

Tasks cannot be set offhand. Accurate records must first be kept of amounts of work done and their costs. All

* See paper before the American Society of Mechanical Engineers by H. L. Gantt.

conditions must be considered. With adequate information it is possible to set uniform and equitable tasks. Such tasks will be the basis of deciding upon wages.

Deciding Upon Wages

A fair basis to both the employee and the employer must guarantee to the average workmen a living and equitable wage. This once established, the best workmen can be induced, by means of a bonus, to do a greater amount of work and thus earn for themselves an increased compensation. They will at the same time earn for the contractor an additional profit. The contractor must be fair in this. He must be willing to share such increase of profits with his workmen, including machine runners, foremen and superintendents. Tasks once set should not be changed on a given job as the changing of such things means the loss of the confidence of the men, who will then condemn the entire system. A contractor would not like to have his prices reduced after making a contract with the owner, so he must realize that the workmen will not stand for a reduction of the money they have been earning.

The tasks set, and the bonuses to be guaranteed, must vary with different classes of work and upon different jobs. Tasks can be set on an hourly basis, for a day, a week or a month and, on short jobs, for the job. The office work is not necessarily increased by this method, but the unit costs of all work will be materially reduced. Even the office and superintending forces can be placed upon the same basis.

One effect of this method of rewarding workmen is to get rid of all workmen who are not bonus earners. They do not have to be discharged; most of them will leave of their own accord or their fellow workmen will cause them to leave. On the other hand, the best workmen within reach of the contractor's work, due to the fact that they can earn an increased compensation, will be attracted to the job. Soon all men become bonus earners, the organi-

zation is materially strengthened and the contractor reaps a decided benefit.

Further Incentive To Workmen

Instructions, tasks and many other subjects outlined in the principles of modern management all serve to increase the output of men and machines, yet these things likewise have a tendency to make a man an unthinking machine and rob him, to some extent, of his individuality. If this is done entirely, there results an injury to both the workmen and the contractor. To prevent such damaging tendencies, a further incentive must be held out to the men to make them think and to give to the contractor not only the results of their new ideas, but also the knowledge that all the men have gained during their lives.

The organization is benefited by any suggestions or knowledge that the employes possess or may gain while carrying on their work. For such information there must be some basis of rewarding those who may give the contractor helpful suggestions. When such things have proven their merit, they must be incorporated into instructions to the men.

A committee made up of workmen and representatives of the contractor can decide upon the value of all such suggestions or ideas, and setting a cash price upon them, the wide-awake employee can be paid an extra reward. This will give all employees an incentive to think and keep thinking and attempting to devise new methods to increase their own output and that of machines. This may be in connection with the work that a man is doing himself or with that being done by others.

CHAPTER VIII

COST KEEPING AND BOOK-KEEPING

Twenty years ago few cost records were kept. Contractors did not seem to realize their value. Then came a great wave of cost keeping and cost data. Many engineers and contractors were carried away with a seemingly new subject and enthusiasts talked and wrote of costs, believing that a knowledge of costs constituted everything necessary to success in contracting. Some young men even believed that a book on cost data and a few thousand dollars were all that was needed to make a success of contracting.

Then came the re-action. Costs were not followed so closely and some engineers and contractors began to scoff at cost keeping and cost data. Notwithstanding their beliefs to the contrary cost keeping is essential to modern management.

Costs and Prices

First, one must understand the distinction between costs and prices. Costs are either real or estimated, and show what expense is involved in any work. A profit is never shown in a cost. Prices, though, should show profits. In other words, cost plus profit gives price. Unfortunately for some contractors this is not always the case. Published costs generally have some value. Published prices of construction work seldom have any value save to make comparisons as to how contractors may bid or look upon work from different view points.

If bids are unbalanced, even prices will not serve this purpose. So long as units of work remain the same, prices of labor and supplies are known and methods used are

described, a list of costs possesses some value. Costs kept by one contractor possess value to others, but their greatest value is to those who compiled them.

Cost Keeping

Many engineers and contractors do not seem to grasp the full significance of cost keeping. Some seem to think it is necessary to compile a great mass of data. Others believe only a few examples are needed, showing extremely low costs or very high ones. Others take a few records, calculate unit costs from them and consider, if they are favorable, that all their work is being handled in a satisfactory manner.

A few contractors, after obtaining complete records of a few jobs, believe that cost keeping is no longer necessary. Some say the greatest value of cost keeping is that it enables one to become an encyclopedia of costs and to be able to use them in estimating upon new jobs.

This is a valuable use of cost data, but its greatest value is in eliminating wastes from the work being done. Study of costs enables contractors to learn the most economical methods of carrying on construction, and decide upon the details of management.

Thus from cost keeping we obtain cost records, and this recording of costs is an endless task, going on hour after hour, day after day, month after month, and job after job. The many features of cost keeping, as applied to management rather than to estimating, will be discussed in detail.

Cost Forms

A contractor doing small jobs and a limited amount of work under his own supervision can keep costs in a memorandum book or in a time book. When much work is being done—more than one man can look after—costs must be kept on forms for that purpose. For large operations

No._____ **DAILY REPORT.** _____1912

EXCAVATING

Monday	Laborers	Per Hour	Total Hrs.	Yards Dirt	Cost pr.yd.	Yds. Rock	Cost	No. tms.	Tot. Hrs.	Cost	Yds. shovl	Yds. Wagn.	Yds. scrp.	Powder
Tuesday														
Wednesday														
Thursday														
Friday														
Saturday														
Sunday														
Weekly Exp														
Weekly Rec														

CONCRETING

Monday	No. Lab.	Av. pr. Hr.	No. Hrs.	Bbls. Cem.	Tns. Cht.	Yds. Sand	Bbls. Wat.	Cst. Tms.	Gasol	Steam	No Feet wlk. Built	Ft. Crsn.	Cu. Yds other wrk.	
Tuesday														
Wednesday														
Thursday														
Friday														
Saturday														
Sunday														
Weekly Exp														
Weekly Rec														

FOREMAN

FORMS

Mon	No. Lab.	Cst. pr Hr.	No. Hrs.	Cst. Stks.	Linl. Ft.	Sqr. Ft.
Tues						
Wed						
Thurs						
Fri						
Satur						
Sun						
W Exp						
W Rec						

TILING

6 in.	8 in.	10 in.	12 in.	15 in.	18 in.	24 in.	30 in.

GENERAL EXPENSE

Monday	Repair	T. Keepr	Engin'r	Watchman	Rent	Tel&Off Supplies	Ins.or Leg. Exp.	Int. and Discount	Tr. Ex	Supt	Am. Mat.	Am. Rec.	Tot. Ex.	Recpts
Tuesday														
Wednesday														
Thursday														
Friday														
Saturday														
Sunday														
Weekly Exp														
Weekly Rec														

GRAND TOTAL

FIG. 3.—A form covering too many classes of work.

such forms can be printed, but where only a limited number of forms are used, the forms can be made with a duplicating machine, at a small expense. It is also advisable when making new forms to try them out and see if changes are necessary by first printing a supply upon some duplicating machine. When the form is found to be satisfactory, it can be printed. The sizes of forms and other details have been covered in The Economics of Contracting, Vol. II. Such forms can be devised to cover a variety of work, but this means to have large forms and many blanks left on them each day, thus wasting much printing and paper. It is better to have small forms meant for only one or two classes of work. If different men do different parts of the same class of the work, then the reports of each man should be on separate forms. After the reports are turned into the office the different operations and their costs can be assembled on a single form by a clerk.

The form (Fig. 3) is arranged for four classes of work and space is provided for general expense. While this is called a daily report, space is provided for six days. Hence it is a weekly report. The amounts of the general expense items should never be known to the men, as these overhead charges are confidential, and, if kept secret, the contractor's costs will not become known to his employees or competitors. This form cannot be commended. It does not give enough detail as a daily cost report and too much is shown for a summary. In each case it entails a large amount of clerical work to obtain unit costs or even total costs.

The form shown in Fig. 4 is not a good one. The labor side is little more than a daily time sheet or pay roll with a distribution column. If twenty names are listed and six classes of work are performed the time of each man must be taken from the sheet and the various items calculated. The amount of each class of work done is not listed. It is not possible, therefore, to figure unit costs from this form. The same costs could be kept in a time book by using symbols to show classes of work.

By placing the materials on the same form it can be seen

COST SHEET

JOB NO. _____

LOCATION _____

NAME OF JOB _____

DATE _____

LABOR							MATERIAL					REMARKS
No.	NAME (Write Plainly)	No. of Hours	Rate per Hour	Occupation	Class of Work	Amount	Material Received	From Whom	Material Used	Cost per Unit	Amount	

FOREMAN SIGN HERE _____

FIG. 4.—A form without unit costs, listing both labor and materials.

that if the men are doing excavation, and do not use any materials, and should none be received on the job on that day, half the report is unnecessary. Labor reports and material reports should not be combined.

Separate Blanks for Each Class of Work

It is the author's opinion that too much stress cannot be laid upon the importance of keeping separate blanks for each class of work, especially on large jobs. In addition to the value of the actual cost records it is thus possible to see who is responsible for high costs. If the reports are grouped it is not always possible to do this and the employees handling such reports will learn the costs of only the work they do and will not know what is being done by other forces.

It must be remembered that cost keeping does not end when such records are made in the field. Aside from the field work there must be some office work to complete the costs. For some classes of work costs must be grouped together in the office, after which they are analyzed and recorded as permanent records. Cost forms may be made up as punch cards or they may be upon instruction cards issued to foremen and workmen. This makes it necessary to keep costs in detail on separate blanks.

It is not necessary for men to take cost forms into the field except when the forms are made up as punch cards or instruction blanks. Ordinarily the men know what facts must be reported and these can be jotted down in a cheap memorandum book. The form can then be filled in at the end of the working period. Thus the memorandum book may become soiled, but the report blank is kept clean, which would not be possible if it were carried around over the job.

Who Should Keep Costs?

This question is sometimes asked by contractors, but more frequently by their men. The answer is that the

men should, as much as possible, keep the costs. A teamster doing hauling should make his records of time, mileage and loads of various materials hauled. A carpenter framing timber should show the work he does on his instruction card. A drill runner should record the holes drilled as well as the lineal feet of and time on each hole. A foreman in charge of a crew working with picks and shovels should report the force at work, the amount of work done and the cost. This does not mean that these men keep time, for timekeeping should be distinct from cost keeping. The operator of a machine must make a report of his and the machine's work.

It is not always possible to have costs kept in this manner as some competent workmen can neither read nor write. Also, some write so poorly that their reports are unreadable. It is necessary to render assistance to such men and this can be done by the time keeper, a material man or clerk or even by the superintendent. Some judgment must be displayed in having costs kept, especially under adverse conditions.

At times it is said that an untrained man cannot be expected to do clerical work. But it seldom takes more than a few minutes to fill in a cost keeping blank and any man should be able and willing to do this. One contractor is known to have said that he did not want a man in his employ who had so little interest in his work as to refuse to do so small a task. Cost recording is as much a man's duty as it is to do his other work.

Material Reports and Stock Books

In addition to records showing costs of the work of men and machines, there must be kept, on forms provided for the purpose, a record of all materials and supplies received and used. From these records invoices are checked and costs of materials and supplies are figured. Then too, from these same reports, stock record books are kept up to date to show just what materials are on hand each day.

In this manner materials and supplies can be ordered ahead so that delays need not occur. In this way the contractor avoids keeping excessive amounts of materials on hand that may not be used for some months.

The stock books tell instantly the amount of materials and supplies on hand. Only a few minutes daily need be devoted to keeping these records correctly. And keeping such records makes frequent inventories unnecessary and saves hours spent in going over reports. This means so much work that a guess may be made to obtain the amount quickly—and such a guess will in all probability be incorrect.

If only a small amount of materials and supplies is used on a job, a time keeper or some other employee may have time to keep the record and handle the reports. If, however, the job is a large one and thousands of dollars worth of supplies and materials are used, one or more material men or clerks may have to be employed. Contractors lose much money through the waste of materials and supplies. Therefore the work of material men is quickly paid for if they properly attend to their duties.

If blanks are used to show the amount of materials and supplies used daily on a job, these items do not have to be listed on a cost keeping form, for it will be necessary to show only the total amount (in dollars) on the cost records. The original material reports can be consulted for details.

Cost Records Should be Kept in Detail

Many engineers and contractors, though strong advocates of cost keeping, do not believe in keeping costs in great detail. If costs of concrete are kept they may record the labor materials, and form costs and the general items of expense. If such costs were to be used for estimating only, these details may be sufficient in most cases. If, however, the costs are meant to control waste of labor and materials and to be used in deciding upon better and more economical methods, these costs cannot be kept in

too great detail. Thus, cost keeping for concrete construction should show the amount and price of cement, sand, and the aggregate. The labor records should show the cost of getting ready to mix and place concrete in the morning as well as the cost of cleaning up after the day's work. The cost of handling the cement bags, and of feeding the mixer, the labor cost of operating the mixer, and the prices of gasoline, oil and waste should be recorded. And the cost of transporting and placing the concrete must not be overlooked.

On form work the contractor should keep a record of the cost of materials as well as of labor in framing, erecting, wrecking and cleaning the forms. The records must show whether the forms have been used before and how often. Form costs may be kept to show the cost per thousand feet of timber used, the cost of forms per cubic yard of concrete or per square foot of surface. It is always necessary to keep form costs by at least two of these three methods.

With costs recorded in such details it becomes possible, by daily comparisons, to detect at once any waste of any kind of material.

The same is true of labor. It may be seen that an hour a day is wasted in getting ready to mix in the morning and in cleaning up at the end of the day. By study this waste may be reduced to less than one fourth of the time. The cost of feeding a mixer may be excessive. If the costs are lumped this fact may never be known. With detail costs, however, the contractor can see at a glance where he is losing money or neglecting a chance to increase his profit.

Fig. 5 is a form for excavation which gives detailed information about the work.

What is applicable to concrete may also be applied to all other classes of work. Excavation, paving, pipe laying and etc. To have the costs in details so that the results can be used at once the units of work done must be reported.

These units will vary on different kinds of jobs and for different classes of work. In some cases it may be

JOB_____ _____

STA. NO._____ WEATHER_____

GRADING REPORT
HAND WORK

Forces	No.	Hours	Wages		Cost		Cu. Yds	Cost Cu. Yds.		Remarks
Foreman										
Pickers										
Shovelers										
Dump Men										
Extra Men										
Drillers										
Drill Runners										
" Helpers										
Blasters										
Loaders										
Boys										
Wheelbarrows										
Carts										
Cars										
Wagons										
Explosives										
Scrapers										
Plowing										
TOTAL										

Haul_____ Feet Earth Rock

Lineal Feet_____ Cubic Yards_____

Number Blasts_____ A. M.

" " _____ P. M.

Cost _____ Lineal Foot

" _____ Cubic Yard

Number Stumps Blasted_____

_____
Foreman

FIG. 5.—A well-devised form for hand grading or wagon roads.

necessary to use several different units as in form work for concrete and in road and street construction where the

cubic yard, lineal foot or square yard may have to be used.

A man day or a machine day is one kind of a unit, but these will be expressed in other units. For instance a man day for shoveling earth may be expressed as ten cubic yards, so in the end we get to the cubic yard basis, which is the real unit of work done. To record such details may mean more work, but it is essential. Just how essential may be emphasized by the following quotations from a business magazine.

"A business concern is a ship ploughing through waters of competition. The rocks which threaten are Carelessness, Laxity, and Waste. The ship sinks . . . the concern fails . . . not because of the big holes staved in the sides. These are apparent. All hands rush to them, and danger can be met and averted. It is the *little leaks*, the scarcely perceptible cracks, which wreck the ship. These are overlooked. In time they cause the whole ship to be submerged. Stop the little leaks. Watch for them. Keep the machinery well oiled, and make all hands work in harmony. Let the man in the pilot house have absolute power. Then steer a straight course for the port of efficiency . . . which is the Harbor of Success."

A detail cost keeping system is the only means of discovering these leaks and placing the man in the pilot house (the contractor) in control. With the details before him, he can steer towards the harbor of 100 per cent efficiency.

Signing Reports

It is necessary to make men sign all of their reports as this fixes the responsibility for each report and the work that has been done by the man signing it or his crew. Also, it causes a tendency for a man to make a more accurate and honest report than he would if he did not have to sign the statement. Most men will refuse to sign a false statement, but they may not hesitate to make a false statement to which they are not compelled to affix a signature.

The most important reports should not only be signed but they should bear the signature of the general foreman or superintendent to show that he considers them correct. Provision should be made on every cost keeping form and daily report for one or two signatures.

A Complete Cost Keeping System

A complete cost keeping system must cover every feature of a job. It must cover more than costs, for the costs, if they are to be used to eliminate wastes, must be supplemented by minute daily records of the operation of machines. Thus, a steam shovel may load three hundred cars in a day, yet be idle three hours. Cost records may not show this but a daily report showing at what time each train went under the shovel and the time it left, as well as the breakdowns of the shovel, will tell whether the machine has been busy throughout the day. The same thing applies to other machines. All lost time, no matter how caused, must be accounted for. This is a feature that plays a prominent part in modern management.

A complete cost keeping system must include some forms by means of which the accuracy of the regular reports can be checked. Otherwise the recorded costs may be erroneous.

There must also be checks for honesty. Some men may steal. Others may not be dishonest yet they would willingly deceive their employer. Such checks as these are almost obligatory.

These forms used may seem to be useless to those who have to make them out, yet they are necessary and fit in well with the system.

To be of the greatest value, costs should be available and analyzed daily. To have this done quickly and along the same lines daily, a cost keeping system must include a number of sheets upon which all of the costs are assembled, totaled and analyzed. Thus many deductions can be made and discrepancies discovered.

From the analyzation sheets the total costs can be recorded so that a comparison can be made with the adopted standard. This is very important and without such a form a cost keeping system is not complete. It makes the data easy to refer to and the results can be used constantly for comparison.

Such comparisons will help to stop the little leaks as well as the big ones and will aid the contractor in adopting the methods that will be most likely to give the greatest efficiency.

Establishing Tasks and Bonuses

By studying the cost keeping system and daily report blanks it is possible to set tasks and offer men a bonus for extra work. A few records will not serve the purpose. There must be records covering a long period of time—a period of depression as well as inflation, times when men and machines work their best and their worst. It is then possible to set a fair task that can be maintained throughout the job.

Book-keeping

It can be seen that cost keeping is not book-keeping, but is supplementary to book-keeping.

Book-keeping for a contractor can be very simple. All book-keeping is similar, no matter what kind of a business is being operated. In contracting, however, there is no selling expense. Thus there are but two or three accounts to be kept. The largest end of book-keeping for a contractor is in recording expenditures, and these are easily handled if properly systematized. If the work is done daily, the book-keeping of a large business can be handled by one man in a few hours.

Even with branch offices and a number of different jobs going on at the same time, there need be but a few books. Yet it is possible to take off a trial balance daily. Thus a contractor, knowing his finances, can arrange, days and weeks in advance, for such matters establishing and main-

taining excellent credit. Most contractors balance their books but once a month, while some only at the end of a job. It is quite a task with the ordinary method of book-keeping to take off a trial balance. It is this fact, coupled with the chance of making errors, that deters most book-keepers from taking off trial balances frequently. Banks take a balance daily, and do it quickly. The ordinary bank handles many items daily—many times more than does the average contractor. Therefore, if it is possible for a bank to take a trial balance daily, it should be possible for a contractor to do the same thing. By doing so it is possible for a contractor to supervise his finances as easily as he keeps in touch with the unit cost of his work. He can control his expenditures as well as his income, and arrange with his banks for help if it is needed. This can be done whether the contractor is doing one job or a dozen jobs scattered over several states.

With the proper book-keeping system there is not a duplication of accounts, even if a number of different jobs are being carried on away from the main office. The sub-offices do but little book keeping, and pay out only such money as is absolutely necessary. All large payments should be kept under the supervision of the contractor or his immediate representative.

CHAPTER IX

SYSTEMATIZING CONSTRUCTION

With the aid of costs and with a general knowledge of construction, a system can be devised for carrying on contract work. It is possible to devise a system without costs or cost keeping, but such an arrangement will not prove so efficient. It is not possible to devise a perfect system—one that is one hundred per cent efficient—but any one experienced in construction can devise a system that will be of great value. From time to time the system can be changed and strengthened to make it more and more efficient.

Books of Rules

Modern system must be founded on rules, yet a book of rules is not a system, in spite of the fact that a contractor's book of rules has been published and advertised as a system. The rules lead to system, but system must embrace all those features that are advocated under the title of modern management. By description, concise rules and photographs, the foremen must be told how to do their work. The office work, as well as the field operations, must be described. The cost keeping must be explained and the care and operation of machines emphasized.

Some of these things can be covered in rules.

Rules are a great help to contractors as they save much time and worry. Rules can govern the employment of men. Any foreman, mechanic or machine operator applying for a job can be allowed to read the rules. Thus he is advised, before beginning work, how he must govern himself, what his duties are to be, and what is expected of him. If he agrees to obey the rules he cannot object to making out reports and performing other duties.

The rules will also tell the men who can hire laborers and mechanics and under what conditions, and when men can be discharged and who is to pay them. In fact all rules and regulations governing the employment and handling of men should be listed in the first part of the book of rules. As examples of such rules the following are given.

Rule 5.—Laborers can only be employed by the superintendent of the job.

Rule 6.—A foreman can discharge a laborer for insubordination or fighting. If the laborer does not seem to be proficient in the work he is doing the foreman must promptly call the superintendent's attention to the fact and abide by the latter's decision in the matter.

Then should follow rules covering daily reports and cost keeping. In this part of the book copies of the forms themselves can be given, properly filled out, so that new men will have a sample to guide them. Rules should also be given telling when these reports should be made out and turned in, so that all such data will reach the contractor's office promptly. If necessary, time keeping and expense accounts can be covered in the same section. The following rule serves as an example.

Rule 32.—All daily reports must be handed to the timekeeper at the office within an hour of stopping work. This applies to both day and night crews.

The next part of the book can be devoted to the organization, showing, by diagram, and rules, who is in charge of different work, and to whom each employee reports. Such rules prevent friction.

It is possible to show the nature of an organization by charting it as on page 133. This diagram is of a large corporation, and follows somewhat the lines described by the author in The Economics of Contracting, Volumes I and II.

A second organization is shown in the diagram, on page 133. This can cover either a private contracting firm, an individual organization, or a chartered construction company.

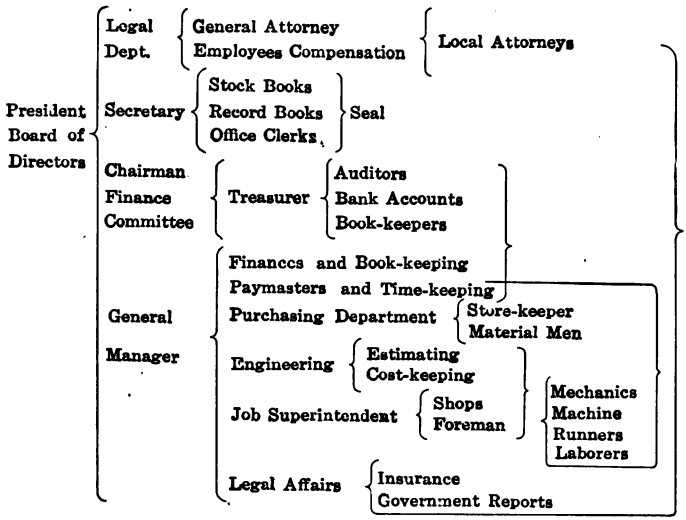
President, Board of Directors
Legal Dept.
General Attorney
Employees Compensation
Local Attorneys
Secretary
Stock Books
Record Books
Office Clerks
Seal
Chairman Finance Committee
Treasurer
Auditors
Bank Accounts
Book-keepers
General Manager
Financcs and Book-keeping
Paymasters and Time-keeping
Purchasing Department
Store-keeper
Material Men
Engineering
Estimating
Cost-keeping
Job Superintendent
Shops
Foreman
Mechanics
Machine
Runners
Laborers
Legal Affairs
Insurance
Government Reports

FIG. 6.

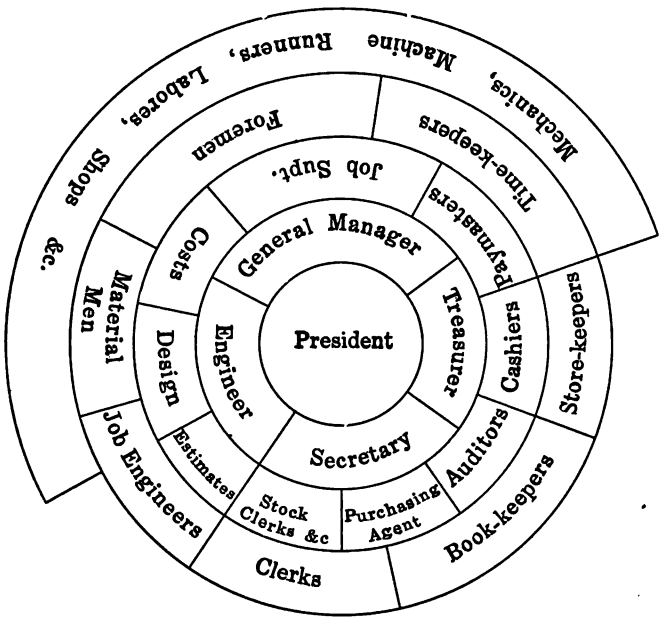
President
Secretary
General Manager
Treasurer
Engineer
Job Supt.
Paymasters
Time-keepers
Foremen
Machine Runners, Laborers, &c.
Mechanics,
Store-keepers
Cashiers
Auditors
Book-keepers
Clerks
Purchasing Agent
Stock Clerks &c
Estimates
Design
Costs
Material Men
Job Engineers

FIG. 7.

A third plan of organization is shown in Fig. 8 on page 134.

These are given as samples only, and are not recommended for any contractor. It is advisable to devise an organization chart for each firm to suit its particular work.

The next section of the rule book can govern the care of tools and plants and their maintenance. For instance, one rule should state that "sharp-edge tools must not be thrown into a chest, but must be placed in racks provided for them." (The care of tools and machines is discussed under another section in this chapter.)

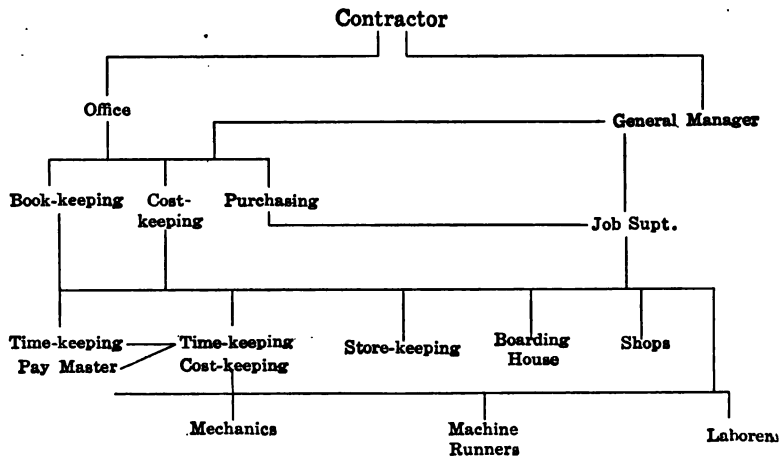

FIG. 8.

The next section should cover "safety first" and should include all rules and instruction as to how machines should be guarded, and the care that should be exercised to prevent accidents. Also, in this section, directions can be given as to reports of accidents. The rules should also explain that compensation to injured men has been provided for according to the state law.

The next section should be taken up with general rules governing the work, so as to prevent useless labor being performed and materials wasted. For example:

Rule 87.—Foremen shall not allow men to walk when

shoveling, or have materials dumped upon the ground so that they will have to be rehandled.

Rule 92.—Stone, coal and similar materials will be dumped upon boards or into bins to prevent waste.

Some blank pages should be provided in the book so that special rules governing some particular job can be written or pasted in the book. For instance:

Rule 119.—Under no circumstances will an employee be allowed to cross the railroad tracks on this job. All employees must go under these tracks. Anyone, even the superintendent, who crosses the railroad track will be discharged.

These sections should for most classes of construction, complete the book of rules.

System on Contracting

A system for carrying on construction can be made up in the form of a book, or it can be mapped out on sheets of paper, or even can be memorized. The most common practice is to have the contractor and his general manager memorize it. For a limited amount of work and with only one man in charge of all operations, the last named method can and does give fair results. Such a system is always changing. Things are forgotten. Untried and unsuccessful methods are used. Mistakes are repeated. Each new thought is tried, without mature reflection. Nothing is certain from day to day.

When a system is mapped out on paper better results can be obtained, for not only will a great deal of time be given to the subject, but also deep and mature thought. Consequently the results are likely to be better. With the papers convenient to consult, the system will be followed from day to day, and with the experience gained, many improvements will be made. Thus each year more economical results can be and are obtained. A system not outlined on paper does not improve so rapidly nor are the improvements necessarily permanent.

For a limited business and for only a few classes of work, a system need not be very extensive, and only a few sheets of paper may be needed to cover a contractor's business. However, every contractor hopes to make his business grow—to obtain more and larger contracts. Hence, his system must keep pace with his business. Thus he will soon have many loose sheets of paper, that will be difficult to handle and will become disarranged. There is always the chance of some sheets being misplaced or destroyed.

For these reasons it is advisable to use a book for recording the system devised. For a limited business only one book may be needed. As the business grows it may be necessary to have several copies. These need not be printed, but can be written out or reproduced on the typewriter. In this form it will always be possible to use the books for quick reference. A loose leaf binder can be used, which makes it possible to change, take out or destroy old leaves and add new ones.

Using this method, it is possible to have different books or binders for different classes of work. The first section can be devoted to the general system of carrying on any job or the different classes of work. There can be sections covering excavation, concrete construction, highway work, sewer construction and other lines. The section covering the general system can be duplicated in each binder, but there is seldom need for the various classes of work being duplicated in the same book. If a business becomes so extensive as to demand many copies for constant use, and the system is well devised, it may be advisable to have the books printed. The same remarks are applicable to the book of rules. Printed books are a good thing, but they are not absolutely necessary to economical management.

It must be remembered that system is much broader and more comprehensive than rules. Rules tell what a man can do and what he will not be allowed to do. For example: Rule No. 20, may say: "A foreman must see that red lanterns, properly filled with oil and lighted, are displayed at all points of danger along a street or highway at night."

While Rule No. 30, may read, "Manila and hemp ropes must not be stored in the same tool box with oils or grease of any kinds."

System goes farther than this and tells how gangs must be organized, how machines must be operated and how all kinds of work done. Books on system are, we might say, short treatises on various kinds of construction, telling when to do things, how to do them, and the results to be obtained.

Thus there must be written instructions, plans and sketches and even photographs, describing and illustrating the work in detail. In Chapter VII mention has been made of issuing instruction to mechanics and laborers. With a book on system all general instructions can be included. Also all standard plans and instructions as to certain classes of work that will be repeated on different jobs can be included in the book on system. This will be the means of saving much work. If plans are too large or too expensive to include in the book on system, then reference can be made to such standard plans, and copies of them when needed can be obtained from the office.

It is by compiling and devising a system that the construction knowledge of every man in the organization can be used as well as the experience of other contractors and the knowledge gathered from technical papers and books. Modern management is not complete without the kind of system here described.

Modern management can in many ways effect many savings but to obtain the greatest efficiency in construction, there must be the proper organization and a modern system. The system is the result of these various studies and cost keeping. Every contractor has some such system, but most of them are crude for they have not been planned with sufficient care.

Consequently the suggestion made is not new. Man has used these general methods since prehistoric times. Noah had specifications to govern the building the Ark, so he must have mapped out a system before he began to cut the tim-

ber and build the frame. The only thing modern about the idea is to base the system on intimate knowledge and so compile it that the same methods can be used by an entire organization, working on many different jobs. This has been done by contractors, and today is being adopted by more and more construction companies.

Some call these systems red tape. They are not. Red tape is such rules and regulations that add to the cost of work and bind those who are working, so that they accomplish little save to keep the expensive system going. In other words the individual is so bound by red tape that at times he becomes helpless.

It is readily possible with a system that has not been planned on paper, that it can develop into one of red tape. But if the system is disgrammed, given a fairly practical test; then if it becomes cumbersome the "red tape" will probably be noted and eliminated.

In other words the weak points are discovered and everything that hinders the men in doing efficient work is eliminated.

Much that is considered red tape is not, for few men will take the time to think out why certain things are necessary. They jump quickly to wrong conclusions.

Departments in Contracting

System will lead to the establishment of departments in a contracting organization. During the past decade it has become evident that many workmen, foremen and superintendents specialize in certain classes of work. Thus some men do nothing but excavation, others work only in concrete and others are expert on sewers. Most contractors must do all classes of work. In order to compete with other contractors there must be men in the organization skilled in the various classes of construction. If a contractor is doing a limited business he switches from one to another as occasion demands. A firm doing an extensive business has departments, each with its own organization.

To strengthen the organization the company should be re-organized to suit conditions. A competent man, experienced in one class of construction, should be placed at the head of a department that will devote its time to that class of work. There can be few or many departments—one for concrete another for foundations and one for sewers, highways, buildings, bridges and etc. Such an organization will obtain work when contractors following old methods will be hunting for jobs. At times, one department may cover several lines such as roads and streets, sewers and waterworks, foundations and tunnels. It may be necessary to shift men from one department to another, but provision can be made for such contingencies.

Some contracting companies are making rapid progress by having various kinds of departments. This is a much better system than having different contracting companies cover each line of work as has been done quite extensively in some sections of the United States and Canada.

By having departments the need for dividing books on system into smaller volumes for different classes of work, is apparent. Thus the books do not have to be made so large and can be used more easily. Money is also saved as useless parts are not duplicated. Each book contains only the information that the user actually needs. There will always be some rules and some part of the system that will have to be duplicated for all of the departments and in most cases the book of rules will govern all of the departments.

Amount of Work to Do

A system is not complete that does not cover in some manner, the amount of work that is expected of an organization, either from certain machines, a given size gang of men or from a combination of both. Conditions vary so much on each job that this is not an easy problem to decide, yet men will fail to make money for a contractor if this important point is not covered.

It may not always be possible to decide on a certain amount of work of a certain class that must be done on every job, but some idea can be obtained for each particular job.

For instance consider steam shovel excavation. A certain size of shovel on one job may excavate, in ten hours 600 cubic yards, on another job 400 cubic yards, while, on a third, it may only excavate 200 yards. An average of 300 cubic yards for these jobs will mean nothing, for on one, this average cannot be obtained and on the other two the shovel crew could loaf much of their time and exceed the average.

Still it is possible to set a standard. With modern systems, the estimated cost should be figured on an estimated yardage that can be moved. For one job this may be 250 cubic yards and for another 500 cubic yards. These estimated amounts can be used as the standards for these jobs, unless it is shown that they can be exceeded. If they are too large they are still kept as the standard, so as to make the machines equal the amount if possible.

The same method can be used to give the men standards with machine drills, concrete mixers and other machines as well as for hand and team work. In other words, modern management leaves nothing to guesswork. Every effort must be put forth to gain accurate information. The old methods of letting these matters take care of themselves should be obsolete. They are wasteful and extravagant and too often lead to failure.

Construction Easily Susceptible to System

When one makes a study of these matters it is quite surprising how many classes of engineering and architectural construction are susceptible to system and modern management.

One class of work that is common today is concrete construction. It is the foremost line in adapting itself to modern management. The fact is that more has been

done with concrete in this connection than with any other line. Concrete jobs have been finished quicker, a finer quality of concrete has been secured as well as more profit by the use of modern methods.

Yet other lines yield the same results. Excavation—a class of work upon which contractors lose much money—can be and is being handled successfully under the principles outlined in this book. This includes all classes of excavation—railroads, wagon roads and streets, canals, reservoirs, cellars, ditches and trenches, dredging, dykes and levees, and many others.

"Factory" tells of one interesting case:

"Eighteen men at work in a borrow pit had in their average ten-hour day been sending down twenty dump cars of clay to the site of the dam which was being built in the river below. Three weeks later, under a new boss, the gang had been reduced to twelve men and was averaging sixty cars a day, with a high record of eighty loads in ten hours.

"What's the answer? Management. The second manager knew how.

"A Y-section of track extended on either side of the borrow pit. Two cars were placed on one branch and loaded simultaneously by separate gangs. Before they were filled a pair of empties would come back and be placed on the other branch. The loaded ones would then be dispatched, and the gang, moving over to the other branch, would begin loading the pair of empties.

"First, the new manager straightened the track and made one man foreman of maintenance of way. Result: No more derailments. Second, he grouped the gang into two sections, one of Neopolitans and the other Calabrians in about equal proportions. Result: Natural rivalry. One day a workman struck a green branch in the top of the load of the car first filled. As the car rolled down the Y the gang which had won the branch cheered its 'side.' A precedent had been established. The green branch had come to stay.

"Other factors aided in the men's enthusiasm as the work progressed. The walk from one branch of the Y to the other gave the 'cheering' and 'cheerless' gang two minutes' rest in every ten. Each man was taught how to use his shovel—each as he proved his worth was paid the maximum wage on the job. But what welded the gang into an effective, contented working unit was the green branch.

"Management assumes a knowledge of men's motives. What appeals to one does not 'sell' another. There are many 'green branches.'"

Rock excavation and blasting can be readily systematized. The fact is that blasting is more effective and done at less cost when carried on along tested lines and on a well thought out system, than when using haphazard methods. This has been demonstrated again and again in tunnel excavation. Numerous articles in the engineering journals will affirm this statement.

The same thing can be said of the quarrying of rock. System and scientific management are reducing the cost.

Brick work and stone masonry as well as timber and steel construction are all susceptible to modern management. This list covers various classes of work under the headings of materials moved or used, and another list could be given according to structures, which would include buildings, bridges, subways, sewers, reservoirs, dams and filtration plants.

Construction Difficult to Handle

In the author's opinion the principles of modern management can be applied to all construction with success. There are, however, some classes of work that are difficult to handle. Two of these are deep foundations, especially under water or in a crowded city, and street paving. In such work it means that a closer study must be made of the many details. It is by keeping costs of details that such studies can be made, and if the small things are first made right, the larger operations will be handled with more ease.

Unfortunately for contractors the engineer for the owner is frequently the cause of making the conditions surrounding the construction more difficult. On one occasion the author called the attention of a contractor to the fact that some street work the latter was doing was being handled poorly. His reply was:

"Yes, sir, you are right. This is a poorly run job. There is a general lack of system. The men and the plant are not being handled according to any pre-arranged or well thought out scheme; nor is the work being done at a low cost. A profit is being earned, but it is small compared to

what it should be. Much of the plant is often idle, as you now see and a large per cent of the materials have to be handled and re-handled, while the forces are moved from place to place, seemingly without reason.

"Some little of it is our own fault, but most of it is due to the engineers in charge, who really let the work before it is ready, and before arrangements are made for the various details to be properly attended to by the other parties interested. Figuratively speaking, we are up a tree to know from day to day, what will be our next step."

Unfair specifications and forms of contracts hit a contractor hard, but these are as nothing compared to delays and hindrances placed upon a contractor, by an undecided engineer who is unprepared and indifferent as to what is due the contractor. Contractors too frequently have to contend with such engineers.

Modern management can also be used to advantage in handling such engineers, both on private and public work. A contractor planning work must consider these things and he must consider a stubborn arbitrary engineer, just as he takes into consideration a difficult ledge that he must excavate.

System must also cover the care of tools and machinery in which every contractor has much money invested. The expense of repairs and renewals is a continual one. Tools are lost, stolen and broken, causing a decided waste even on small jobs. A system of caring for the plant and of keeping account of each tool and machine, in order to reduce the expenditure in this connection, is necessary.

Records of Tools and Machinery

All construction plants can be classified under two heads, namely, tools and machines. Under tools are classed all of those implements that a man can lift and use, including a hundred or more articles such as shovels, picks, hammers, saws, wrenches, bars and wheelbarrows. Under the heading of machines come all of those implements operated by hand or by mechanical power that are too large to be moved easily by hand. This division includes pumps,

mixers, excavators, hoisting engines, cars, wagons, derricks and a multiplicity of other machines.

A record should be kept of every tool and machine owned by a contractor. To do this it is necessary to adopt some well thought out system. If a contractor is working but one gang under his own supervision or that of a single foreman, using only small tools and a few machines, the record can be kept in his head and possibly nothing will be lost. But if this system is carried on when other jobs are taken and the forces are increased (as they are in most cases), the memory becomes overtaxed, and tools are lost, stolen and used up and money is wasted without the waste being realized. Besides this, there is no record of repairs made to each machine, and only the general charges for repairs show in the ledger.

In all systems, there must be a central tool house and storage yard. This tool house may be the office or a building or room. It is used to house tools and small machines that are new and have not been issued on the job, as well as old tools not being used. Under the heading "tool house" in the book is listed everything in reserve.

If an accurate record is to be kept of small tools, a hard and fast rule must be made at the start that employes must not bring their own tools onto the job. The contractor must furnish all tools needed. This prevents men from "swapping" poor tools for good ones; prevents them from claiming tools as their own when they belong to the contractor, and allows the latter to direct the use of all tools and machines as he sees fit. If this rule is deviated from in the least, confusion is caused and the contractor is bound to lose money. The only exception to this is in the case of carpenters. These artisans, in many sections of the country, furnish their own tools, such as hammers, saws, chisels, planes, augers, squares and screwdrivers. In such cases the contractor does not furnish these men anything but the larger tools so no confusion is caused.

There must be a suitable tool box or house provided for keeping tools when not in use. These boxes can be numbered or be denoted by the name of the foreman. Tools taken from the tool house are listed on another page in the record book and credited as coming from the tool house. The dates are set down in each case so as to keep a complete record. .Thus there is a list of tools remaining in the tool house and a list of tools in each box, with the dates issued. Those remaining in the tool house can be checked off and a new list made to make it easier to refer to. At the end of each week, or at other suitable times, the contents of each tool box can be checked up to see if all are on hand.

To illustrate how this is done, imagine that two shovels, three picks and two eight-pound hammers are short in one box. The foreman states that the shovels were broken and he threw them away, that he sent the three picks to the blacksmith shop to be sharpened. He says he did not need the two hammers and allowed another foreman to have them. He is informed that the parts of all broken tools must be saved in order to have them checked in or new ones issued in their place. When tools are sent to the shop to be repaired he is furnished with a slip to be used for the purpose, such as the following:

Date.....

Please repair the following tools, returning them to me:

.....Shovels.	Repaired and returned.....
.....Picks.	Repaired and returned.....
.....Drills.	Repaired and returned.....
.....	Repaired and returned.....
.....	Repaired and returned.....

Signed.....

Foreman.

FIG. 9.

This order is made in duplicate by using a sheet of carbon paper. These slips can be printed or a supply may be

made on a typewriter. They can have the names of many different tools placed on them or space can be left for writing the name. In the column "Repaired and Returned," the blacksmith marks the date of his work and, if necessary, the hour. He then places the slip on a filing hook. If everything sent to the shop is accompanied by a slip a complete record of the blacksmith's work is obtained. If more than one man is employed in the shop, each places his initials against each item of work he does.

With a duplicate slip in the foreman's hands, the blacksmith is responsible for these tools until he returns them to the foreman. If it is desired to have the blacksmith do some special work, the foreman writes the order on the back of one of these slips and if he is skilled enough he can make a rough sketch on the slip and place on it the dimensions. If a sketch is necessary and he cannot do it, the order should be sent to the contractor's or superintendent's office and placed with the smith from there.

When the tools are returned to the foreman, he marks on the duplicate slip the date of receiving them. Thus his record is complete, and if his work has suffered for the lack of them he can show that the blacksmith kept them longer than necessary. If it was not the blacksmith's fault, the blame is fastened upon the foreman for not sending to the tool house to get extra tools to replace those being repaired. For obtaining such tools the foreman can use an order similar to the following:

Date.....

Please send me the following tools:

.....

.....

Order filled..... .....

Entered..... Foreman.

FIG. 10.

If the order is not filled it is returned to the foreman and destroyed. If it is filled, the clerk marks on the slip,

at the proper place the date, and when he enters it on his books he marks that date, and files the slip. The foreman marks on his duplicate the time the order was filled, thus completing the record.

If one foreman gets tools from another he sends an order similar to the above to that foreman. The foreman filling the order marks on it when filled and keeps the order. Thus when his tools are being checked up and he is short two hammers, he produces the slip to clear his own record. The clerk then takes the slip, credits the foreman with the two hammers and charges them to the other foreman, marking on the slip the date of entry. This makes it necessary for the other foreman to produce these tools.

On the inside of the lid of the tool box, or in the tool house, a list of the tools can be kept attached to a board or in a slide made for the purpose. Only the clerk has authority to change this list and he revises when he checks up the tools. The foreman is thus held responsible for all tools charged to him unless he produces parts of broken one or produces slips showing that the tools have gone out of his possession.

This general method is suitable for all jobs, for it keeps a record of each tool, accounts for broken ones and those worn out and keeps a record of repairs as well as of new tools issued from the reserve supply. The cost of the slips, whether printed or written, is small compared to the saving they effect.

The rule regarding showing the parts of broken tools must be rigidly enforced. The author has refused to furnish a new hame string to a driver without his paying for it, unless part of the old one was brought to the office, tool house or stable. It is not necessary for a foreman or workman to wait until the tools are checked up to get a new one to replace old ones. They can be presented at any time and new tools issued in their place. If a foreman understands he is responsible for all tools issued to him he will care for them. The author has known foremen to keep a record each day of tools issued to each laborer in a

memorandum book so he could check them off at night, and that foreman kept his tool box locked during the day. It is needless to say the work did not suffer from this.

To prevent tools from being stolen they must be marked in some manner. One method of doing this is to use a brand with the contractor's name or initials on it and to burn these into wooden parts of the tools. The metal parts and tools can be stamped with a steel die. For close inspection this method answers the purpose, but at a distance tools cannot be told from those belonging to another man. By painting parts of the tools with distinctive colors, using the brand and die to identify them further, they can be recognized at a distance. Thus hammers, picks, shovels, etc., can be painted blue from the head, part way up the handle; another contractor can use green and so on through various colors and shades. Two colors can also be used on the same tool. Some of this paint will wear off quickly but some will stay on during a season. The paint also protects the tools. All new handles can be painted before they are put into the tools.

For large machines, such as derricks, cars and mixers, the same color scheme can be carried out. With two distinct colors adopted as a standard, the painting can serve as an advertisement. The contractor's name can be painted on them, given further publicity. On some machines it is also possible to paint numbers.

It seems almost useless for a contractor, operating in a small way, to keep a record of the few large machines he may own, but this number within a few years may be much larger. Even if the number does not increase, it is a record that is easily kept and the information as to date of purchase and maker's name may prove valuable. Such a record may be kept in the small book with the tool records.

The system outlined for keeping a record book of tools and machines is not well adapted to large jobs or for use by a contractor running a number of different jobs. When a number of contracts are being carried on at the same time, the main office is not so much interested in the particular

point on a job a certain tool or machine is being used, but rather what tools and machines are on each job. The local office looks after the record of where tools and machines are located on each job. Thus there are two records to be kept. It can be seen that the local record for each job can be kept in the manner already described for a small job, but to have the entire system fit the main office records and make the whole system of records interchangeable, the card index system should be used.

A card index system is adapted both to tools and to machines. There are three general sizes of cards used in these indexes. The smallest size is 3×5 inches, the medium size is 4×6 inches, while the large size is 5×8 inches. Any of these sizes can be used, but for most purposes the smallest size is not large enough. The second size is large enough for small tools, and by using a card $7\frac{3}{4} \times 6$ inches, folded so as to be 4×6, a larger card is obtained than by using a 5×8. This is the size the author prefers for small tools, while for machines the single 5×8 gives ample room, especially if the back of the card is used. With these two sizes the home office record can be kept and likewise that of the local office.

The $7\frac{3}{4} \times 6$ size is used at the main office for small tools and at the local office for both tools and machines. The 5×8 size is used at the main office for machines only. The small tools are handled in a manner similar to the record in the book. Tool boxes and tool house records are made out on the cards and filed according to jobs, index guides being used to show the cards for each job. New tools purchased or sent to the job are listed on additional cards and placed in the files. Duplicates of all of these cards are sent to the job so that the local office has the same record as the main office. At the local office these cards are filed and as tools are used up and marked off the record, at monthly intervals, this record is sent to the main office. At the local office new cards are also made out, one for each tool box, and each week or at any time decided upon for checking, these are carried out upon the job and check made

for each foreman or tool box. The repair and order slips shown are used in connection with these cards.

This gives a system that can be kept up-to-date, as cards with many corrections on them can be thrown away and new cards substituted.

The cards may readily be referred to in a filing cabinet and a duplicate can be used to keep in the tool box or house. With the cards it is also possible to make many subdivisions, having a card for each division, and by numbers, letters or other symbols keep these cards together.

At the end of a job the card file is taken to the main office. There it is checked up with the card records and, as different tools are sent to other jobs the corresponding cards from the local office are sent to the jobs where the tools are to be used.

The machine record is kept in a slightly different manner. First it is necessary to have name and number plates made bearing the contractor's name. A place for a number and any other information is provided. These plates are fastened to the machine in a manner similar to that used in attaching manufacturers names. These plates not only tell who owns the machine but also allow a number to be used to keep a record of the various machines. Numbers in series can be used, such as 1–99 for mixers, 100–199 for pumps, 200–299 for dump wagons, and so on through the list. These numbers are stamped on the name plates. Consecutive numbers can be used as various kinds of machines are purchased, but by this method the numbers will not be a guide to the kind of machine, as they are when series are used. The numbers are stamped on the name plates with small steel dies. The date of purchase can likewise be put on the plate in this manner.

These plates should be used even if the machine has the contractor's name and a number painted upon it, for the paint can be worn off, thus erasing name and number. The plates should always be kept clean so that the name and number can be read at all times. If more than one machine is rigged on one piece of plant the entire machine should be

given a number and each separate machine a number. Thus a record can be kept of each piece of machinery whenever it is transferred and even if several items of plant are assembled to make one piece of apparatus, such as a stiff leg derrick, a grab bucket and a hoisting engine being mounted on a car or skid to make an excavator.

The size of card recommended for the main office is 5 × 8 inches. In the example given a concrete mixer is listed. This is shown by the name. The description shows that it

NAME *Concrete Mixer*	REPAIRS DATE	REPAIRS CHARACTER	REPAIRS COST
DESCRIPTION *Mixer, gasoline engine & hoist*	*4-2-1911*	*Purchased*	$1,000
MANUFACTURER'S NAME *Mixer - Success Mfg.Co.*	*7-4-1911*	*Main gear on mixer*	5 10
Engine - No Name Engine Co.	*10-11-1911*	*Cylinder head-eng*	4 25
" NO. *Mixer - 921 Engine - 1642*	*10-22-1912*	*Overhauled, new bolts & nuts*	8 20
OWN NO. *Mixer - 62 Engine - 122*	*2-1-1914*	*Small gears replaced*	
SIZE *No.1*		*Painted*	18 75
CAPACITY *½ cu.yd.*	*9-10-1914*	*Overhauled, New*	
DATE OF PURCHASE *4-2-1911*		*Charging hopper,*	
REFERENCE: CATALOGUE *Mixer - 1911 Cat.No 22*		*Painted, etc.*	85 50
LIST FOR REPAIRS *Engine - 1911 " List attached*			
H.P. *2½*			
REMARKS			
TOOL BOX ON MACHINE *9 in.oiler 1 qt.grease pot,*			
machine hammer, 6-in.cold chisel, 10-in.double			
s wrench, 16-in.double s wrench, 14-in.monkey wrench			
14-in Stillson wrench, 16-in.screw driver			

FIG. 11.—Record card for large machines. Size 5 × 8 in.

is a concrete mixer with a gasoline engine and a hoisting charging hopper. Under the manufacturer's name is shown that the mixer was made by the Success Manufacturing Company, while the gasoline engine was made by the No Name Engine Company. The contractor's own numbers on the name and number plate that he has had placed on both the mixer and the engine are, for the mixer, 62, and for the engine, 122. The manufacturer's numbers are also given. These numbers will be found of use in ordering new parts. The size of the machine is listed as well as the capacity. Both of these must be known and if

they are not kept in the record expensive delays will often be caused while this information is obtained. The date of purchase is placed on the card.

The reference to the catalog is to make it easy to obtain a description of the machine, its shipping weight and also in ordering new parts to get the right name and number in order to prevent costly mistakes. There is also the reference to the catalog of the engine company. The parts of the engine needed for repairs have been printed on a sheet and the notation shows that this repair list has been attached to the card. The horsepower of the engine is recorded. There is a place provided on the card for remarks.

On the right of the card is a space properly ruled to keep a record of the repairs on the machine. Here can be recorded the date of purchase which can be omitted on the left of the card. The original price of the machine is given in the cost column. The record shows that the main gear wheel was replaced on the mixer on July 4 of the year it was purchased and the cost of it, including the labor of replacing, is given. The next entry shows that the cylinder head of the engine was repaired a few months later and the cost of this is shown. A year later the entire machine was overhauled and new bolts and nuts placed wherever necessary. On February 1, 1914, the small gears on the machine were replaced and the entire plant cleaned and painted. During the autumn of that year the plant was overhauled entirely, a new charging hopper placed on it and the machine was painted. Thus a complete record is shown of the first cost and all money spent on repairs and renewals. The entire record is in concise form and of easy reference. Likewise the condition of the machine is shown. It is also possible, from such a record, to figure the interest and depreciation on the machine.

At the bottom of the card it is shown that there is a tool-box or chest on the machine. The contents of this box are listed. This can be entered on this card or can be recorded on another card and attached to this one. If the list is a long one the latter is the better plan.

The faces of the cards give a very complete record of all machines owned by the contractor. The back of the card is reserved to show where the machine has been worked and is now located. This is shown in the other form illustrated. On this side of the card there are only two headings, "Jobs" and "Yard." This record is easily explained. When it was a new machine it was sent to the Mission street job on May 11, 1911. Finishing its work there it was placed in the contractor's storage yard on September 4. On March 5, 1912, it was sent to a job on Deering street. Finishing there it was sent to Boltstown on July 8 and returned to the storage yard on October 12, 1912.

JOBS:	YARD
5-11-1911 - Mission Street	*9-4-1911*
3-5-1912 - Deering Street	
7-8-1912 - Boltstown	*10-12-1912*
4-2-1913 - San Juan	
2-6-1914 - Sumner Street	*9-1-1914*
2-14-1915 - Bakersfield Reservoir	

FIG. 12.—Reverse side of Fig. 11.

On April 2, 1913, the mixer was sent to a job at San Juan and used there until Feb. 6, 1914, when it went to a job on Sumner street. On September 1 it was returned to storage and started the season's work on Feb. 14, 1915, at the Bakersfield reservoir. This record shows that in about 46 months since the mixer was purchased it has been idle about 18 months, thus working about 28 months. The record of work done, shown on the back of one of these cards, can extend over a number of years.

If it is deemed advisable, a separate card can be made for the engine and kept in the record with other engines, but this, in the writer's opinion, is not necessary unless the engine is separated from the mixer.

A busy contractor can obtain much information in a few minutes from a card like this. He is able to see

what care is being given to each machine, the time it is worked and when it is idle, the cost of repairs and how one make of machine stands up with that of another manufacturer. With the catalogue reference it is always possible to compare the machine with a new catalogue to see what improvements have been made, making this a guide in buying a new machine.

For a limited business a contractor or his general manager can go over every card in the index within a reasonable time. If large operations are carried on (a number of different jobs in various localities and extensive plant on each) the head of the company would find it a tedious task to go over all the cards in the machinery index. To overcome this a wall board can be used to show the location of the principal items of plant.

This board is made quite large and has rows of holes bored into it with spaces between the holes to insert tags with thumb pins. These tags bear the names of the different jobs. Under these tags or labels in the holes are placed wooden pins with button heads on them. On these buttons are placed the numbers of the various machines. These buttons can be made of different shapes, round, square, rectangular, triangular, diamond shape, etc., each shape showing a different kind of machine. A color scheme can also be used to show different kinds of machines. The numbers on the buttons can be in white or black. Thus if machines are numbered in series, for instance, mixers from 1 to 99, steam shovels from 100 to 199, and so on, then if the buttons under one job show numbers 62, 78, 101, 204, 205, 310, and so on, the contractor knows at a glance that there are two concrete mixers, a steam shovel, two locomotives, and so on through the list.

If different shaped buttons and colors are used these things can be more easily impressed on his mind. If he desires to know the particular machines, their sizes, etc., on any job, he orders the cards for these numbers to be brought to him. This wall board does not take the place of these cards, but is merely a graphic aid to the busy

contractor to keep posted as to the disposition of his plant.

The small tool boxes on machines are treated in the same manner as are the tool boxes belonging to the foremen. That is, the tools are charged to the man in charge of the machine and each week they are checked up. Any shortage must be accounted for in the manner previously described.

Some machines have only a few tools on them while others, such as a large steam shovel, have quite a number. Few or many, they should always be on the machine as they are liable to be needed at any minute not only to prevent break-downs but to make quick repairs. This alone shows the need of keeping an accurate record. These, too, are the tools that mechanics like to own and they are continually claiming the contractor's tools as their personal property. It is to prevent this that they should not be allowed to bring their own tools to the job.

Every machine should be equipped with suitable tools for placing packing, as nothing injures machines so much as being improperly packed. In the case of steam, it means a great waste of fuel. If a machine is not so equipped when purchased such tools should be purchased or made.

It is also necessary to purchase tools in addition to those furnished by the manufacturers for some machines. Soft hammers are needed, otherwise men will injure bearings by hitting them with a machinist's hammer. Wrenches, of different sizes and styles are generally needed. On some machines there must also be some wood-working tools, such as saws, hammers, hatchets, chisels and auger bits.

All tool boxes should have substantial locks on them and except when the tools are in use the box should be locked. Such boxes should also have compartments in them to hold such brass parts as may be on the machine. Then when the machines are not in use the parts can be placed in the box and the boxes stored in a safe place. This will prevent them from being injured or stolen. Such

tool boxes should be labeled with the same numbers as are placed upon the machines so that they will be known readily.

The filing of the various record cards should be done in filing cases with drawers that just fit the cards. The filing can be done by names of machines, such as concrete mixers, cars, steam shovels, etc. The dividing tabs bear the letters of the alphabet (or the names of the various machines can be placed on the tabs), thus making each drawer self indexed. This answers the purpose for most occasions but it means extra work in finding the card for any certain machine when only the number is known.

For this reason filing by numbers is to be preferred, as then a small card index is made of all the record cards and it is possible, by referring to this index, to get either the number or name. Then, by referring to the record cards by number, the exact card is found, showing the record of the desired machine.

The system described can be kept in an inexpensive cabinet of limited size, for a contractor doing a small business. It can be expanded to cover an extensive contracting business reaching around the world.

Purchasing Materials and Machinery

Contractors waste much money in buying materials, tools and machinery—more than is supposed—unless one versed in purchasing goes over the bills. For this reason, this chapter would not be complete without some comment on this important feature.

Both contractors and manufacturers are interested in the purchasing side of construction work. The manufacturer wishes to sell, the contractor is compelled to buy. On a large variety of construction work a contractor has to spend from 30 to 60 per cent of the value of his contract for materials and machinery. He is interested in securing the best values for his money and at the same time in keeping his purchases to the minimum.

The manufacturer is keyed up at all times to sell. He must insist on a reasonable profit, supply a good product and must furnish a certain service. The manufacturer may also be called upon to help to finance the sale. All of these conditions, and some others, make the subject of selling and buying a very complex one.

Contractors and manufacturers are learning more and more regarding this important subject each year, but as there is not a common meeting ground, except when an actual sale is to take place, these men do not learn from each other very rapidly. In considering a subject of this kind, the rascals must be eliminated—the contractor who is dishonest and the manufacturer who may wish to cheat his customers.

There are two facts regarding selling that few buyers consider. The first is the cost to the manufacturer of finding the customer and making the sale. The second is the cost of collecting the money, with a possibility of losing a part or all of it.

Not only must the manufacturing costs be covered in the sale price, but also the two costs just mentioned must be included. There must be a reasonable profit for living expenses and for expansion.

The cost of finding a customer may be quite a large per cent of the cost of manufacturing. It must cover advertising of all kinds, commissions to salesmen and profits to jobbers and agents. Even after the possible purchaser is found, the actual sale must be made. This may be the hardest part of the work, for several manufacturers may find the same possible purchaser at the same time and, as only one can effect a sale, it may take considerable time on the part of all the manufacturers. The unsuccessful ones must charge this lost time and expense to the sales they actually make.

It may seem that jobbers and agents could be eliminated, but to do so does not necessarily mean the selling cost would be reduced. Some manufacturers have tried to do away with jobbers and agents only to return to that system.

It may be possible for a manufacturer doing only a local business to sell direct, but the company doing business over a large territory must have local representatives.

This is done by selling through jobbers and agents or by having branch stores or offices in the leading cities. The expense of the latter may equal the commission paid an agent or the profit of the jobber, as this expense is constant during the fluctuation of business. The jobber and agent earn money from the manufacturer only as they effect a sale.

Some manufacturers have succeeded in reducing their entire selling costs to less than 10 per cent, a few to less than 5 per cent. Most selling costs, however, will run from 10 to 20 per cent, some over 20 per cent, and some even being higher than 30 per cent.

The fact that a company's selling costs are high does not necessarily condemn it or its products, for its line of goods may not admit of frequent sales. Included in these costs is not only that of finding the customer and effecting the sale, but also that of the service rendered the customer.

The modern purchaser wants service. He wants trials of goods and the return of goods that are not up to his expectation. He wants guarantees and the replacement of all breakage. He wants prompt delivery. He wants his name placed on machines. He wants salesmen to call upon him or demonstrators to instruct him and his men in the use of certain articles. All of these things cost money and must be paid for by the purchasers. When one manufacturer renders this service, another one must.

Demands for service come at all times. On one occasion the author was seated in the office of a concrete mixer agent when the telephone rang. A contractor was having trouble with his mixer.

"Did we sell you the mixer?" the agent asked.

"No, we bought it from another contractor, who purchased from a contractor who bought it from you," was the reply.

The agent went out to see the mixer, spent an hour that afternoon on the job and visited it again the next morning

to right the trouble, which was not with the mixer, but was simply due to a lack of knowledge of operating a mixer on the part of the contractor's superintendent. This was service and it cost money to supply it.

Unless goods are sold for cash there is always some cost of extending credit. No matter how honest a man may be, misfortune may overtake him. He may be buying on long time agreement, giving notes. Thus interest is accruing on money invested by the manufacturer and this must be covered in the price or the buyer must pay interest on the notes.

Even when goods are sold on lease sale agreement and remain the property of the manufacturer until the last payment is made, there is the possibility of having to take back the machinery and the payments actually made may not be enough to cover this cost, the depreciation on the machine and the cost of selling it again.

These two general costs may vary for any manufacturer from season to season so he can only average them over a term of years. Advertising is necessary in marketing all products and this is an expensive item, for in order to obtain the best results, good mediums must be used and these are high priced. In the end, however, they give the greatest value for the money expended. Two kinds of advertising may be done—that of boosting the manufacturer's own products and educational advertising, showing the public the use of the line of goods being manufactured. Both classes of advertising are endless tasks, and an advertiser must continually try new mediums so as to reach new customers.

There is the cost of catalogs, folders, photographs and other means of explaining the merits and operation of the manufacturer's machines or goods. As a poorly gotten-up and cheaply printed catalog gives the impression that the goods are likely to be of the same character, many dollars must be spent for the best that can be produced. The distribution of these things likewise costs money. One manufacturer stated recently to the

author that it cost him a dollar to answer an inquiry for a catalog.

Advertising pays both the manufacturer and the purchaser. To advertise a product continually means that the manufacturer must stand behind his product and that it must be the best that brains and money can produce. This fact is the best possible guarantee to the purchaser. He knows that advertised goods are dependable goods, and that an advertiser has a reputation to maintain. Reputable trade journals do not want the business of irresponsible advertisers, and when readers can show that any company so advertising is not responsible, the journals are glad to eliminate such advertising from their paper.

The manufacturer is usually on the alert to keep his products up to a high standard. This standard may not be set by himself but by his competitors. If the product is clay pipe, the desire is to produce and sell a better pipe than any other manufacturer. If the machine is a steam shovel, the manufacturer wants to build a shovel of better materials, of a more up-to-date design, of a greater range of work and, for a given weight and size, of greater capacity than any other make of shovel. This is the manufacturer's fight from one year's end to the other. Much money that would otherwise be profit is expended in these endeavors.

Manufacturers are frequently large borrowers of money. They use vast sums in extending credit to their customers as previously pointed out, and, to purchase their raw materials at the right season of the year and obtain the lowest prices, they must buy in large quantities and for cash. Hence, large sums of money are generally tied up in the stock piles in their yards or buildings. It is such purchases that mean as low prices on the manufactured articles as is consistent with the quality of the goods and also make possible an even grade of goods being sold to the buyer.

These are the considerations that cannot be shown in the price of an article, and make it almost impossible for a buyer to select his goods or machines upon a price basis alone. Two articles may, to all appearances, be the same,

but one will outlast the other by many months or years. A slightly increased cost may mean that an article will last twice as long.

This is not the only factor for a contractor to consider. In a machine it may mean that his forces will not be delayed by frequent breakdowns. Likewise the factor of "safety first" must be considered. This may also be the case in some materials and supplies. Take, for instance, wire rope. Ask for quotations of several thousand feet of rope and the prices will vary quite a little. A cheap rope may mean that the work may be delayed by breaks and that men may be injured or killed.

These are the general facts from the manufacturer's side of the question of buying and selling. There are other details that could be set forth, but for the present purpose it is enough to state the general features only.

The purchasing end of the business must be based upon these facts and additional ones that are to be considered from the purchaser's viewpoint.

The products that a contractor purchases can be divided into two classes—materials, including supplies, and machines. At one time it was just as difficult to purchase materials in a satisfactory manner as is now the case with machines.

This change in purchasing materials is due to the fact that certain standards have been set for materials by some of the national engineering societies. Cement is manufactured and purchased upon the standard specifications of the American Society of Testing Materials. The American Concrete Institute has adopted certain standards for materials in connection with concrete. The American Society of Civil Engineers has adopted standards for other materials. The Lumbermen's Manufacturers Association has adopted standards for timber. Such standards are becoming generally known among the trade and as contractors learn that manufacturers have adopted these standards, it makes it a comparatively easy matter to purchase most materials.

A list of the probable needs of the contractor, together with the specification of the society or association governing these materials, can be submitted to a number of manufacturers and prices can be asked for, with dates of delivery. This makes it possible, if the delivery dates are satisfactory, to place orders or make contracts based upon the lowest prices.

Disputes are not likely to arise, for the standard specifications will govern the inspection and this can nearly always be done by a disinterested party. In fact there are firms of engineers that make a specialty of inspecting materials, charging a fee for their services.

With machinery, except in some few machines purchased under engineering specifications, this is not the case, and it is especially so with contractors' equipment. What is to recommend a particular type of machine? Testimonial letters are of little value. The majority of these letters are in answer to communications from the manufacturers as to whether a machine has proven satisfactory. It is but natural that in replying the purchaser is likely to say all he can that is favorable. Even if the letter is unsolicited it may mean little for the terms used are general ones and would suit some other machines just as well. Nor is there any guarantee that the writer of the letter is a competent judge of the merits of the machine, either as to its durability or its being the best adapted for the work. In many cases the writer of the letter may never have used any other make of machine and may not possess any particular skill in operating the one he owns. Repeat orders from men who have used a variety of machines are recommendations, but repeat orders from a man who has used only one make of machine can hardly be considered a high recommendation. It simply shows that he has not found fault with the machine, whereas, if he had tried some other make he might have purchased elsewhere.

Manufacturers overlook these facts and use testimonial letters without telling the conditions surrounding the

use of their machines. Recently the author saw the statement of one concrete mixer company, in which it was said that one company owned and used sixteen of their mixers. Such a statement was more or less impressive, but if the actual facts had been given it would have been an excellent advertisement.

This contracting company, doing a large business and making a particular concrete product, has, during 10 years, used and tried out the majority of the various types of concrete mixers. This experience made them decide upon a certain type and size as best suited for their work. Then they tried a number of different makes of this type and decided that the best built and the one to give the best service and results from their standpoint was that of a certain manufacture. Consequently they are using only this make of machine and every repeat order is a testimonial to the manufacturer. This is a remarkable recommendation that few manufacturers have received, yet this company is hardly making the fact an asset.

An attempt is being made to place the buying of goods on the plane of engineering and there has been offered to the public the title of "purchasing engineer." Is this the proper title or is it wise to try to make this work either an art or science? In most mercantile lines, the title that has been in common use is that of "buyer." For large engineering and construction corporations, for the railroads and the large manufacturing establishments the title in most common use has been that of "purchasing agent," a few having used the term manager or director in place of agent.

The buyer or purchasing agent is simply what the name denotes—the man who comes into contact with the seller and does the actual buying. He may be purchasing on exact specifications furnished him, or he may be using his own discretion, knowledge and judgment. He may not place an order before he has consulted with one or possibly several officials of his company. His work may, at times, for a contractor, or for a manufacturer, approach the work and ideals of an engineer; upon other occasions there may

not be any similarity. It may be possible, under some conditions, for an engineer to purchase to better advantage than a man without engineering training; in other cases this very training may prevent the purchaser from buying to advantage.

Hardly any one man, speaking generally, can possess all the technical knowledge and training to make every purchase for some of the largest contracting companies, nor can he possess the knowledge of how certain machines are to be used. Hence the purchaser must rely on others within his organization to some extent, and if he does not possess engineering knowledge he can consult with the engineers from the department for which the purchase is being made. There must be competent advice, and this will come from within the organization in most cases or from outside experts when necessity demands.

Few buyers or purchasing agents would, in the author's opinion, wish to have their titles changed even if they are graduate engineers. Their work cannot be changed by changing their title, and there should be no endeavor to surround their work with mystery. It should be made as open and above-board as possible, to render such assistance as is consistent with the act of buying.

Purchasing must be based on intimate training and knowledge if it is to be successful. The buyer must have an alert mind, know human nature, have general knowledge of both buying and selling, possess knowledge of the wants of his own company and likewise an intimate knowledge of materials and machinery to be bought.

Successful buying is based upon knowledge, and this can be obtained from study and from actual buying. If the purchaser does not know the basis of selling he cannot tell if he is securing low prices. He must understand price lists and discounts. He must know of factory deliveries and other details that will save money.

A very large number of articles are sold on a list price, this list standing for years and the discounts varying from season to season and also from year to year, as the price of

materials that enter into their manufacture varies. Then there are other list prices that change from time to time, on which the discounts remain the same. Thus there may be discounts such as 30 per cent, 10 per cent or 10 per cent and 7½ per cent. The manufacturer may give all of these discounts to the jobber. The latter gives the merchant intending to resell the article 30, and 10 and 10, while to a consumer buying from either the merchant or the jobber, ony the two discounts of 30 and 10 may be given. Other conditions surrounding a sale may cause the discounts to vary somewhat, but if the buyer does not understand the basis of list prices and discounts he is likely to be satisfied with whatever is offered him.

Materials and supplies purchased directly from the stock of either a merchant or a jobber are likely to be higher in price than those shipped from the manufacturer direct. This is due to the fact that the goods may have been bought and paid for by the seller, so he has money invested in them that must earn interest. He has paid to have them put into his warehouse and must stand the expense of handling, packing and cartage to reship them. These things add to the selling price.

If a machine is shipped direct from the factory all of these items are eliminated. The jobber may not even have any money invested in the transaction for he may be paid before his bill falls due with the manufacturer. It is not necessary that an order be very large to have it shipped direct from the manufacturer, but it must come within the rules laid down by the manufacturing associations. For instance, when the author was a buyer he could order 300 pounds of tool steel as a factory shipment, while 275 pounds would be shipped from the jobber, costing from 1 to 2 cents a pound more plus local freight from the jobber to the contractor, while the factory makes a freight allowance on their shipments. To obtain a shipment direct from the factory takes longer, so that the wants must be anticipated and ample time allowed. Car load shipment, except of some kind of mixed goods, can always be made factory shipment.

The method of paying for goods sometimes affects their price. Cash in hand is an asset always, so that cash discounts are offered. Some few classes of goods are sold for cash only, that is, bill of lading attached. In this case, it is only possible to obtain the bill of lading to get the goods from the railroad by paying the sight draft attached to the bill of lading. It is not a question of a man's standing or his credit but the value of money over waiting 10 or 30 days to be paid. These are some of the things for the buyer to know and understand.

For machinery and equipment the buyer must know the needs of his organization. He must not know simply that they need a piece of machinery, but must know the general methods of carrying on their jobs, so as to understand the type of machine needed and the size and the appurtenances to control and operate it. He must know of the machines that are on the market. For some of the latter information he can depend on the manufacturer or selling agent, but there is much that the buyer must know. Naturally each manufacturer thinks that for a certain class of work his machine is best. If he thought otherwise he could not honestly and consistently urge the sale.

This is one of the difficult features of buying construction machinery. The manufacturers use such terms as "economical operation," "durability and superiority," "accessible construction," "low maintenance charges," and "greatest results and best service." All of these things may be true, yet they are applicable to many machines, so they have little effect on the reader of advertisements and catalogues except to confuse him. To a great extent it is these general terms that are likewise used in letters.

The author's preference in such matters is to have a well written catalogue or circular, first telling in detail of the design and construction of the machine, and from this going into the operation.

The range of work of the machine can be shown together with its capacity, its adaptability to different classes of work and the cost of maintenance. If there are any special

features or unusual improvements over other machines of the same type, these things can be called to the attention of the reader in closing. With such a catalogue it is possible to write a letter to a prospective customer and even in a short letter, reference can be made to each feature by page number.

These are the things that an intelligent purchaser wishes to know so that he can make a wise selection. If he is fooled he is not likely to give a repeat order. If a purchaser wishes a concrete mixer, and wants to get the one he believes best suited to build any kind of a small structure, and sends to thirty or more concrete mixer manufacturers for their catalogues and prices, he must either make his selection from the information sent or ask to have representatives call upon him. Not considering the salesmen, it is to be seen at once that, if the printed matter is incomplete and contains only generalities, with a long drawn out letter that is confusing, such manufacturers will be given scant consideration. This may eliminate one-third of the number.

The buyer then begins a close study of the other machines and finds that, as to many details of either construction or operation, the information given is meager. So he disposes of half of the remaining letters at once.

Of the rest, it becomes a question of price, the details of operation, and possibly additional letters are written to clear up certain matters. In a case like this the contractor may have secured a good machine, but not necessarily the best, for it may be that one of those first eliminated from consideration was the best, though its claims were so poorly presented that its merits could not be seen. It is true that a good catalogue has sold a poor machine, while the sale of a good machine has been ruined by poor advertising literature.

Another means of assisting in deciding upon new machines to purchase, is to keep a card index of descriptions of machines and jobs they have been used on. When it is necessary to decide upon these things, consult these cards

so as to understand the economy of operation. Obtain some knowledge of the capacity of the machine under actual working conditions and the range of work. These are facts seldom set forth by the manufacturers, but rather those furnished by some engineer or contractor having experience with the machines. It is not possible to decide upon the purchase from information of this character but it will be of assistance.

Free trials for a period of from 10 to 30 days are of assistance in deciding upon and trying out new types of machines, but this is not likely to be of decided advantage under most cases. After installing such a machine as a concrete mixer, it is better to keep it on the job rather than to go to the cost of putting in place another mixer, with all of the delays of placing an order, receiving and installing the machine and changing the charging and placing methods. Under such conditions, a trial is equal to a purchase, and it is advisable to take more care in selection. Reserve tryouts for such times when they are not likely to interfere with the work and permit more careful comparison.

Another method of assisting in purchasing is to obtain catalogues and other information regarding a machine when there is no idea of making an immediate purchase. In this way ample time can be taken to gather information as to the work it can do, the ease and economy of operation and many other features that may commend the equipment.

Price may count in the purchase but the main point is to have a machine well built so that breakdowns will not be frequent, the machine will do work at a low cost and set such a pace on the job as to save money on every part of the work. These things will count more than a few hundred dollars that may be saved on the purchase price.

With some purchases the selection will be made on a price basis and on the delivery that can be given. This will be for certain classes of machines where the method of operation is the same and where only a few reputable

manufacturers can compete. The decision in such cases will be easily made.

In other cases, as in some power plants, the machines will be purchased on specifications furnished to manufacturers. The following of the specification will count in such purchases as well as the price, delivery and installation. For such machinery the contractor is likely to employ a mechanical expert to draw up his specifications and plans. It will also be possible to have the advice of this expert in selecting the machinery and making the purchase.

CHAPTER X

THE EFFECT OF MODERN MANAGEMENT UPON WORKMEN

While efficiency in construction is the result of system, the system must take into consideration the workmen. Modern management considers not only all the workmen, but the individual, and his knowledge, peculiarities, ability to do work, his welfare and his compensation.

Old Management and Workmen

In many cases the old system of management did not do this. The workman was considered a necessary evil. He was driven to his work, poorly fed, underpaid and made to feel that his position was a very humble one. This kind of treatment does not make a better workman of any man. A contractor of the old school, operating in the south some years ago, used to say: "Kill a mule, buy another. Kill a negro, hire another." This spirit drove men from his employ and made his work cost more.

Another contractor once said: "I do not know the names of any men working on my jobs under the grade of foremen, and I don't want to know their names."

Modern management of men leads to the development of a close relationship between employer and employee and to create this relationship the men must be studied.

Study of Men

Certain features of the study of men have been discussed in the preceding chapters. The labor end of the construction business is of the utmost importance and the last word will never be written on the subject. Many contractors realize this and begin their study of employees by first

obtaining their names. They go so far as to record detailed information about each employee.

Fig. 13 shows a form for this purpose which can be made on a card so that an alphabetical index can be kept of the men. The sample given is used by a western contractor. On this card can be entered the date of employment, the man's name, age, nationality and whether he is married or single. His address and that of nearest relative or friend, his occupation and wages, previous employer

EMPLOYEES RECORD

_____ 191_____

Name_____ Age_____ Nationality_____

Married or Single_____ Home Address_____

Name and Address of Nearest Relative or Friend_____

_____

Employed as_____ Rate Per Hour_____

Where Employed_____ Previous Employer_____

_____

Employees Signature_____

_____ Foreman.

FIG. 13.—Record of employees.

and other information should also be noted. It would be advisable to show the date of leaving the contractor's employ and on the back of the card space could be provided to show promotions received. Other information that would be a help in placing the man and using him on different jobs may be included in the record.

This card is filled out when the man begins work. The card gives a record of the man in case of accident or in case he leaves the contractor and again asks for employment. It can be the basis for a study of each man's disposition, and his knowledge of different classes of work.

It is becoming recognized that in handling men the individual must be studied and placed where he will give the greatest results.

Two men can earn their pay by operating a diaphragm pump all day. The cost of this will be three or four dollars, while for less than fifty cents a day a gasoline engine will do more efficient pumping than the men. Thus, to substitute a gasoline engine for the two men is economical. These two men can be tried at shoveling and, should they prove to be poor shovelers, they may be discharged.

The men should not be discharged because a gasoline engine can do more economical pumping nor should they be let go because they do not measure up to the other shovelers. Possibly if they were allowed to try picking they would prove efficient—possibly turn out to be better pickers than the men already doing that work.

The foregoing paragraphs will suggest some of the studies necessary to economical management. Modern management is also teaching men that laborers should not be worked in large gangs. Men lose their identity by being placed together. Results are expensive and it is difficult to learn what a man can do or for what work he is best fitted. Because of working men in large crews construction has cost more than it should and one of the extra costs has been the indiscriminate discharging of men. Every time an experienced worker is discharged a new one must be trained—and this is expensive. It is doubtful if contractors realize what this one item has cost them.

Some years ago the author took the pay rolls of a large construction company and estimated the number of men hired on each job so as to learn the total number employed to keep the forces up to the number actually needed. It was found that for every laborer actually needed five men had been hired. Thus, to keep a force of a hundred men at work it was necessary, during the life of the job, to employ five hundred men. Most of this waste could have been eliminated.

It is too common a practice for a contractor or foreman to discharge a number of men, for little or no cause. The expense of getting other men and breaking them in is too great to make such procedure profitable. There

may be some fault with the men, but the chances are that it is either with the contractor or foreman or the system of carrying on the job. Contractors, like other employers, go too much on the principle that the boss is always right. He can be at fault just as much as the men.

Espirit De Corps

Let the men know that their employer is interested in them and they will become interested in the work of the employer. It is the part of modern management to foster this spirit. The first principle of this is to let the man's individuality stand out. A record card, as shown in this chapter, gives the man a chance. It shows the workman that his "boss" wishes to know something about him and what he has done in the past. Then, too, the fact that the man is asked to make daily reports and sign them shows that his work is to be known and that he is being made responsible. Every man is pleased when certain responsibility is placed upon him. He begins to feel that he is part of the organization. His work and reports become something that he can discuss with his boss and if this is done with him, pride in his work is encouraged.

Placing a premium on his knowledge and his ability is a further incentive to bring from the man the best that is in him. Thus the tie between him and his employer is being strengthened. He begins to use the word "we" in talking of the job and when a man talks like that it means more dollars in the pockets of employer and employee.

It is also incumbent upon the employer to consider the welfare of his men while at work and rest. This is necessary in towns and cities and more so in "the sticks" where men have but little amusement during idle hours. All work and no play soon makes any man dull.

Institutional Management

The individual employer, the firm or corporation, together with all employees are considered to be an institu-

tion in which there is a common interest and all work together for success. The money earned is divided according to a prearranged plan. The employees receive wages and the employer the profit on his investment of capital. Additional profits earned are divided between employer and employees by special arrangements.

Institutional management places an industrial organization on a higher plane than an enterprise designed to enrich a few at the expense of many. It is not, in any manner, a co-operative scheme, although it demands co-operation from all.

Thus there is effected a management that is divided between the employer, his direct representatives, and the employees. Committees can be formed and societies maintained among the men to further the interests of the institution. These associations can have for their purpose the safeguarding of the lives of the men, the increasing of their output by working more efficiently or the aim may be to increase the profits of the institution, to increase the earnings of the men, to better working and living conditions, to provide more recreation, to educate their children better, to have better sanitation on the work and in the homes, to engage in sports and amusements, and do all of those things that mean living better lives.

These things are accomplished by instructing the man, by meetings and lectures at suitable hours, by providing club rooms or tents for the gathering of all, when not at work or by organizing outings or indoor recreation parties.

Contractors have a great opportunity in this line, for there already exists, in the construction field, a certain brotherly feeling between those engaged in this line of work.

Scientific Management and Workmen

The introduction of scientific management has, at first, a tendency to increase the work of the officials, but this is only for a short time. As soon as the system becomes

understood and the various employees learn their duties and assume their responsibilities, the work of those in charge is lightened. This is aptly illustrated by a statement of a manager, who has introduced scientific management in his company. He said: "We would be swamped with work and every one from our president down would be handicapped, owing to the phenomenal increase in our business, if it were not for our wonderful system, which gives our officials plenty of time to consider ways of increasing the business and making our men contented."

It is possible to have a system that, in many ways, takes care of itself with only a little supervision so that a great amount of work can be done. The possession of such a system is an asset to any organization, and is very essential in contracting where it is necessary to have extra time to bid upon new jobs and start them when they are secured.

Scientific management has just as wonderful effects upon foremen, mechanics and common laborers. It makes men interested in their work and especially in the job. This is the means of leading men to think for themselves and in the interest of the job and the contractor. Further inducements held out to the men cause them to think of ways to increase their earnings—which, of course, means increasing the employer's profit.

One good result of this kind of management is the reduction in the amount of liquor consumed. The men find that when they drink on the work they are not able to earn as much as when they keep sober, so, of their own accord, they drink less—and, in many cases, drinking intoxicants is eliminated.

These things have a decided tendency to make men more cheerful at their work. They realize that they are earning more money and their work becomes a pleasure. The hours pass rapidly, for the workmen are contented.

Scientific management means the selection of the best men. The inefficient workmen are soon eliminated, leaving only bonus earners in the organization. And if only one contractor in a community is applying modern manage-

ment and paying bonuses to his men, this fact will attract to his employ many of the best workmen in that section of the country.

Another result obtained is to keep the same men on the job for a long time. In fact, many of them will remain in the contractor's employ for years. They may leave, but will come back again when they can. This point was illustrated by a story Mr. Frederick W. Taylor told in his book "The Principles of Scientific Management."

"Each ore shoveler was given a separate car to unload each day, and his wages depended on the work he did. The man who unloaded the largest amount of ore was paid the highest wage, and an unusual opportunity came for demonstrating the importance of individualizing each workman. Much of this ore came from the Lake Superior region and was delivered in Pittsburg and Bethlehem in exactly similar cars. There was a shortage of ore handlers in Pittsburg, and hearing of the fine gang of laborers that had been developed at Bethlehem (the result of scientific management), one of the Pittsburg steel works sent an agent to hire the Bethlehem men. The Pittsburg men offered 4 $\frac{9}{10}$ cents a ton for unloading exactly the same ore, with the same shovels, from the same cars, that were unloaded in Bethlehem for 3 $\frac{9}{10}$ cents a ton. After carefully considering this situation, it was decided that it would be unwise to pay more than 3 $\frac{9}{10}$ cents per ton for unloading the Bethlehem cars, because, at this rate, the Bethlehem laborers were earning a little over $1.85 per man per day which was 60 per cent more than the ruling rate of wages around Bethlehem.

"A large series of experiments, coupled with close observation had demonstrated the fact that when workmen of this caliber are given a carefully measured task, which calls for a big day's work on their part, and that when, in return for this extra effort they are paid wages up to 60 per cent beyond the wages usually paid, this increase in wages tends to make them not only more thrifty but better men in every way; that they live rather better, begin to save money, became more sober, and work more steadily. When, on the other hand, they receive much more than a 60 per cent increase in wages, many of them will work irregularly and tend to become more or less shiftless, extravagant and dissipated. Our experiments showed, in other words, that it does not do for most men to get rich too fast.

"After deciding, for this reason, not to raise the wages of our ore handlers, these men were brought into the office one at a time, and talked to, somewhat as follows:

" 'Now, Patrick, you have proved to us that you are a high priced man.

You have been earning every day a little more than $1.85, and you are just the sort of man that we want to have in our ore shoveling gang. A man has come here from Pittsburg, who is offering 4 9/10 cents per ton for handling ore while we can pay only 3 9/10 cents per ton. I think, therefore, that you had better apply to this man for a job. Of course, you know, we are very sorry to have you leave us, but you have proved yourself a high priced man, and we are very glad to see you get this chance of earning more money. Just remember, however, that at any time in the future, when you get out of a job, you can always come right back to us. There will always be a job for a high priced man like you in our gang here.'

"Almost all of the ore handlers took this advice, and went to Pittsburg but in about six weeks most of them were again back in Bethlehem unloading ore at the old rate of 3 9/10 cents a ton. The writer had the following talk with one of these men after he had returned:

" 'Patrick, what are you doing back here? I thought we had gotten rid of you?'

" 'Well, sir, I'll tell you how it was. When we got out there, Jimmy and I were put on a car with eight other men. We started to shovel the ore out just the same as we do here. After about half an hour I saw a little devil alongside of me doing pretty near nothing. I asked him why he didn't go to work. I told him that unless we got the ore out of the car we wouldn't get any money on pay day. Well, the little devil stood up to me and said to mind my own business. I could have knocked him over with my little finger, but the rest of the men put down their shovels and looked as if they were going to back him up. So I went around to Jimmy and said (so the whole gang could hear it), 'Now, Jimmy, you and I will throw a shovelful whenever this little devil throws one, and not another shovelful.' So we watched him, and only shoveled when he shoveled. When pay day came we had less money than we got here at Bethlehem. After that Jimmy and I went to the boss, and asked him for a car to ourselves, the same as we got at Bethlehem, but he told us to mind our own business. And when another pay day came around we had less money than we got here at Bethlehem, so Jimmy and I got the gang together and brought them all back to work again.' "

This strikingly illustrates many good effects upon common laborers due to scientific management. The men, being anxious to make money, start to work on time, instead of using up ten or fifteen minutes twice a day to find their tools and get instructions from their foreman. Then, too, they keep working instead of watching the boss for a chance to loaf when he is not looking.

These things are not surmises but the results of handling men on construction by means of modern management as outlined in this book. The author has seen men using shovels who were unwilling to straighten their backs but a few times a day, as they claimed it interfered with rapid work.

Then, too, good men, without interference from the boss, have made lazy workmen measure up to their standards so that the speed of the job would be maintained. These things have been done in excavating earth and rock, in laying pipe, in mixing and placing concrete, in timber and steel construction and in fact, in nearly every line of engineering and architectural construction.

Results of such work by construction economists and efficiency experts could be given in actual figures that the ordinary contractor would not believe. These results have been obtained and are being obtained more and more as contractors realize that their work can be improved and profit increased. However, if contractors are, like the steel manufacturers of Pittsburg, unwilling to be benefited by the experience of others, their work will cost more without any one profiting by the increased cost.

The ones to be most benefited by the application of scientific management to construction are contractors as they will make in a year, many thousands of dollars in extra profits. Their employees will, likewise, reap benefits and assist in making the new ideas of management a success. In closing Mr. Taylor is again quoted.

"Perhaps the most important of all results attained was the effect on the workmen themselves. A careful inquiry into the condition of these men developed the fact that out of one hundred and forty workmen, only two were said to be drinking men. This does not, of course, imply that many of them did not take an occasional drink. The fact is that a steady drinker would find it almost impossible to keep up with the pace which was set, so that they were practically all sober. Many, if not most of them, were saving money, and they all lived better than they had before. These men constituted the finest body of picked laborers that the writer has ever seen together and they looked upon the

men who were over them—their bosses and their teachers—as their very best friends and not as drivers forcing them to work extra hard for ordinary wages. It would have been absolutely impossible for any one to have stirred up strife between these men and their employers. And this presents a very simple though effective illustration of what is meant by the words 'prosperity for the employee, coupled with prosperity for the employer'—the two principle objects of management. It is evident also that this result has been brought about by the application of the four fundamental principles of scientific management."

APPENDIX

THE ORGANIZATION OF WAR CONSTRUCTION FORCES

Since the text of this book was written the preparation of the United States for the great World's War has necessitated the expenditure of millions of dollars for the construction of temporary buildings and terminals for handling war munitions. This work had to be done quickly, and with practically no preliminary preparation.

Contractors were called upon to finish, in a few months, jobs involving expenditures from a few thousands of dollars to ten millions or more. The uniformly good results obtained, in spite of the necessity for unheard-of speed, can be attributed to the ability of the contractors to quickly outline and build up organizations of almost any size. In many cases from ten to fifty thousand men, with large numbers of machines, were gotten together within thirty days, were properly organized and put to work. The results were not the most economical; the necessity for great speed made it hard to effect savings that would, under ordinary conditions, have been made. In some cases, government plans were indefinite and frequent changes had to be made. But the necessary speed was obtained—and the cost could not be considered excessive under the conditions.

Many lessons have been learned from the experience of 1917, but space will not permit of their being recorded at present. Perhaps the greatest lesson we can learn is by studying the working up of field organizations both in the United States and in Canada.

The chart shown in Fig. A is that used by the contractors who built all the cantonments in Canada. This work

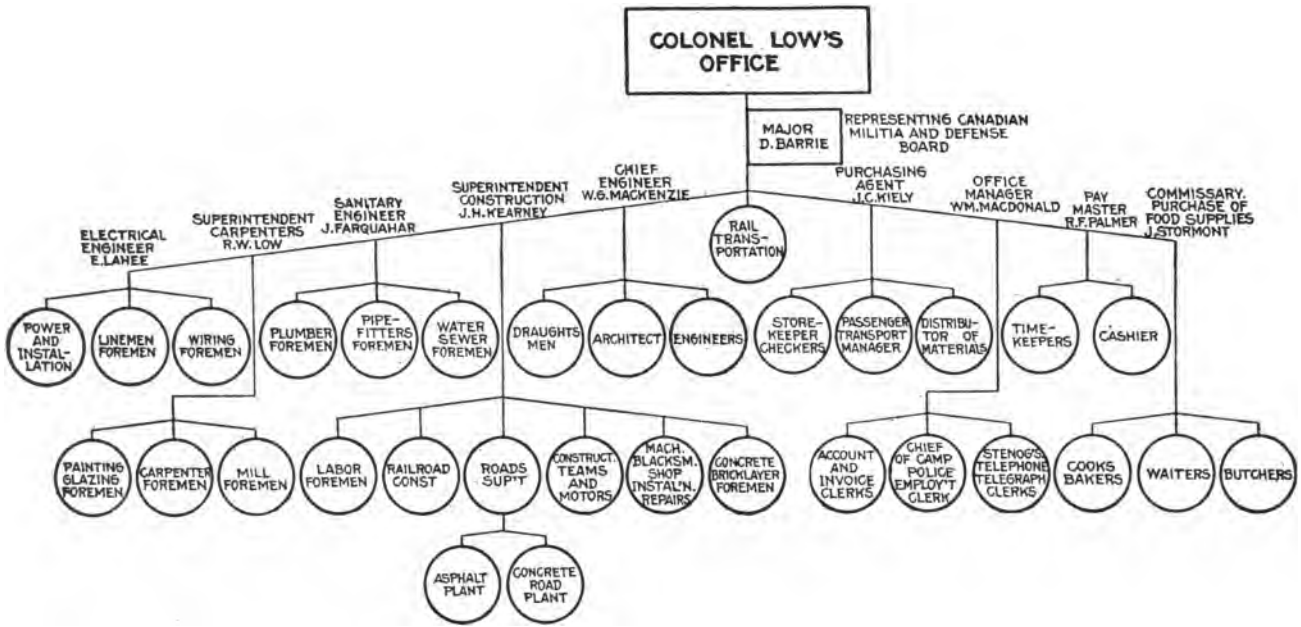

FIG. A.—Chart of Canadian organization.

was not so extensive as that done in the United States, but reports state that the results were commendable.

The general manager of the contractors was made an officer of the Canadian Army and the work was co-ordi-

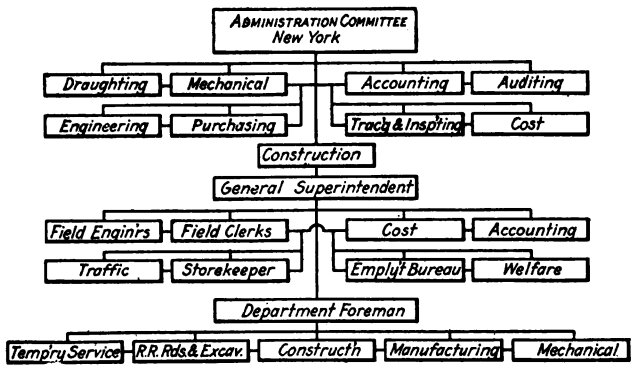

FIG. B.—Camp Upton organization chart.

nated by having all matters pass through the office of a representative of the Militia and Defense Board of Canada.

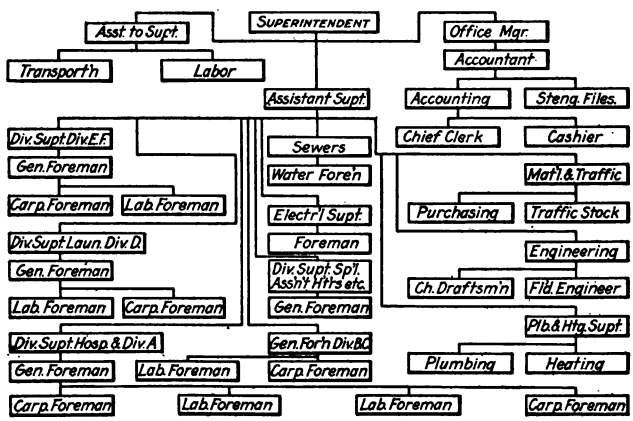

FIG. C.—Camp Travis organization chart.

The sloping lines, starting at the center, are to show the relative responsibility of the various offices and the sequence of the work. To the right is shown the office force and the method of handling the finances; on the left is shown the

actual organization for construction, listing the heads of departments and showing the classes of work to be done by each group. There is, however, nothing to show how the

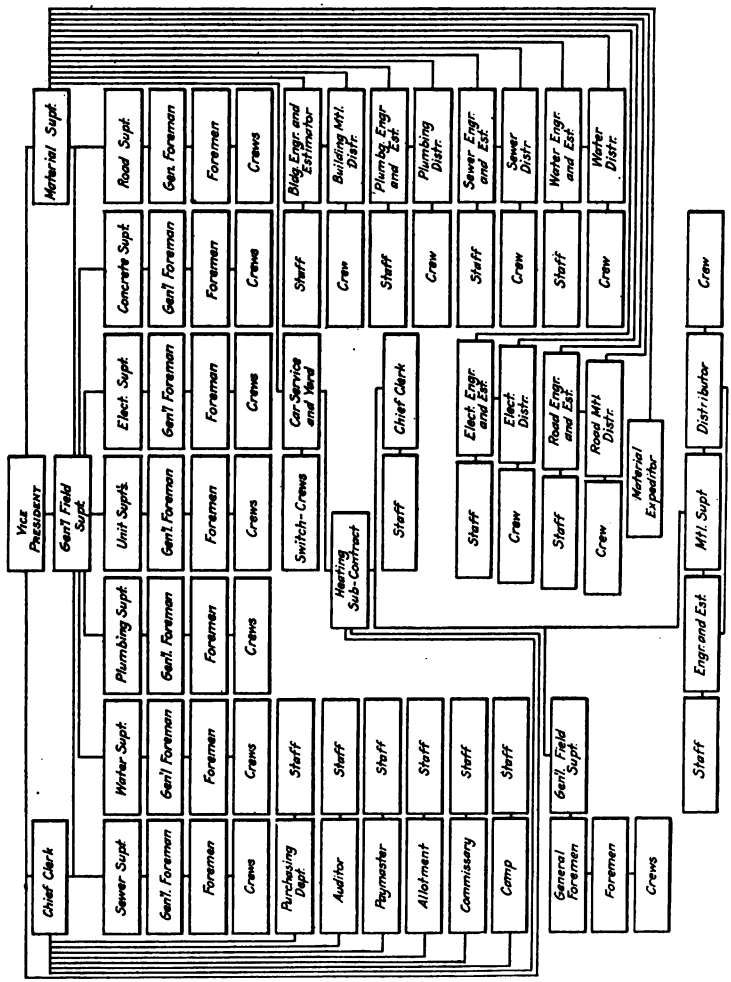

FIG. D.—Organization chart at Camp Grant.

various departments interlock, nor into what units the various forces are to be divided.

The chart shown in Fig. B illustrates the various departments with only one or two executive officers. It shows

only the general method of handling the work, and does not give the various classes of construction to be done.

The chart shown in Fig. C indicates the labor divisions, both for the office and field. This chart is an improvement over that shown in Fig. B, but if the two were worked up together both would be more comprehensive.

In Fig. D, showing the organization used at Camp Grant, this has been done. In this chart the organization of the labor forces is shown, the various materials to be purchased are indicated and the method of handling them is mapped out. Even the organization of a sub-contractor is illustrated. The various classes of construction and the departments for handling each are also charted. This is an improvement over the other charts.

The chart shown in Fig. E is one the author devised for a large organization on a cantonment job. It centralizes the authority under a general manager, and provides for the many different classes of construction that may be involved. It also divides the work into various units and shows the labor organizations for each unit.

If there is not much work of any one class, one superintendent can be placed in charge of two or more kinds of jobs and the general foreman under him will likewise take charge of several classes of work.

If the job is not large enough to warrant this organization, the general foreman can be eliminated. The foremen would then report to the superintendents. If the organization indicated is too expensive for the size of the job, the superintendents can be eliminated. The foremen will then report direct to the general superintendent. This makes a very flexible arrangement.

Because of the flexibility of an organization such as that indicated the work can be divided into units. The breaks in the lines show how the organization can be expanded to cover a dozen units if necessary. On the other hand, the entire job could be done as a single unit by simply contracting the organization.

The financial, engineering, and other departments can

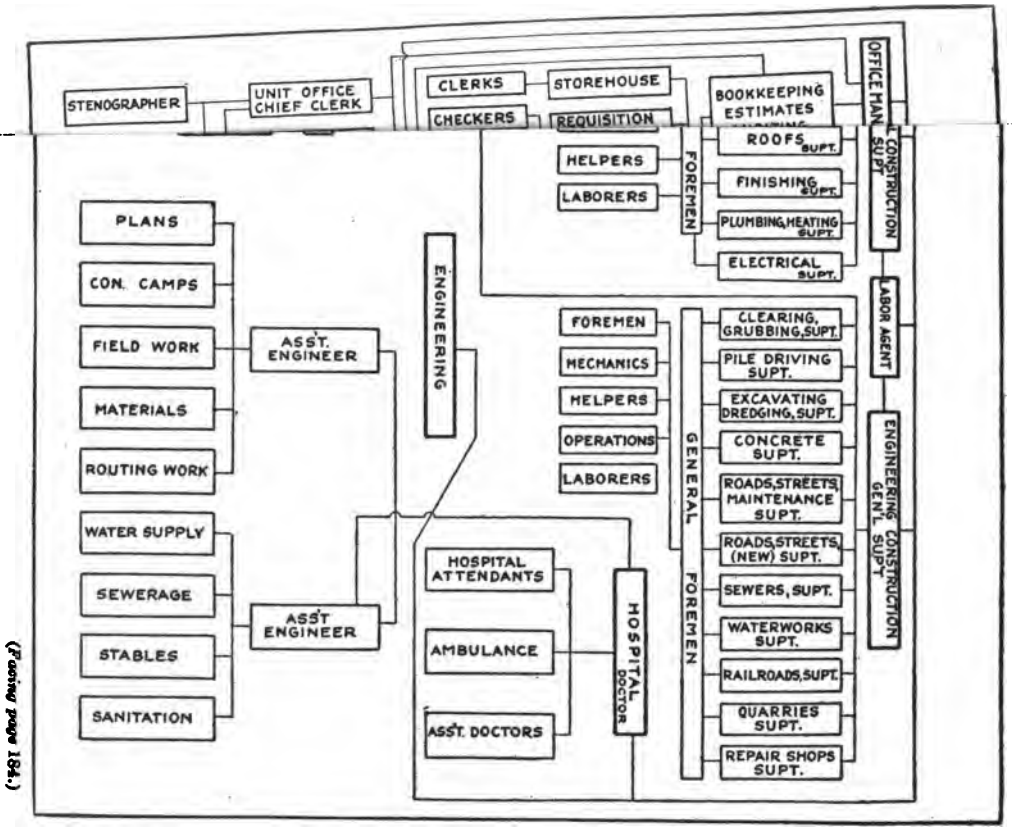

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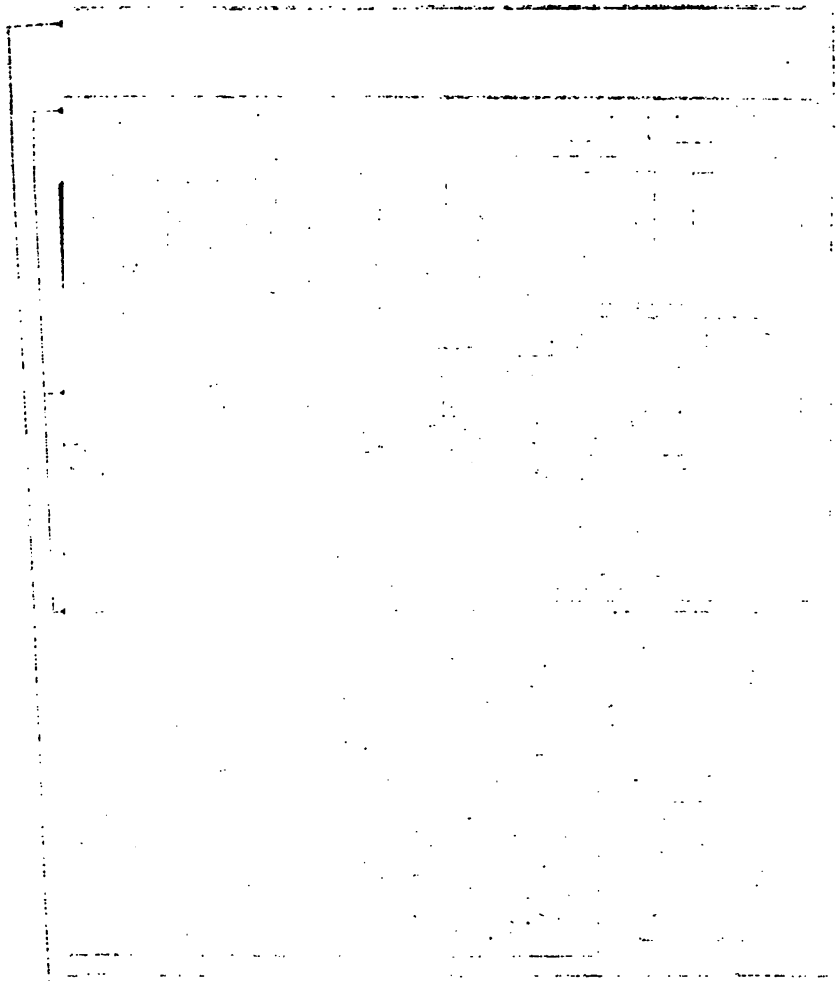
FIG. F.—Chart showing a sub-contractor's organization.



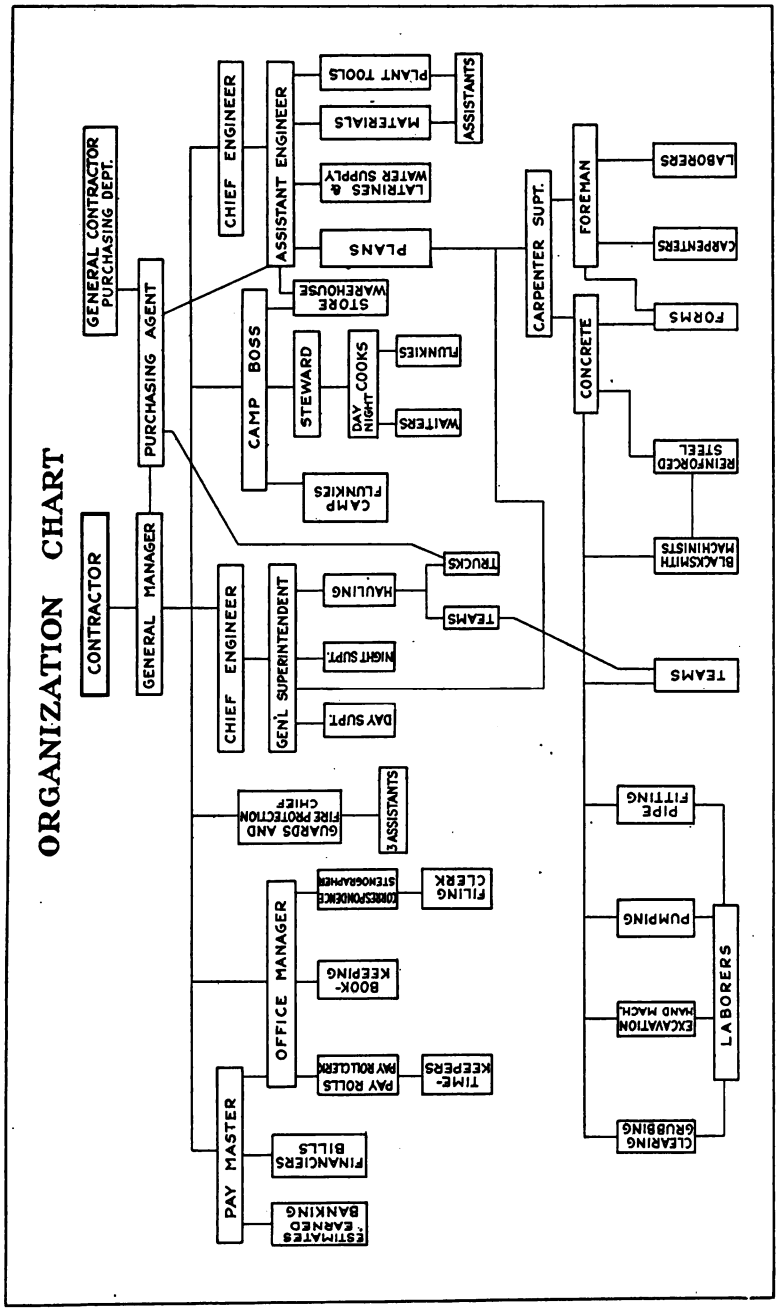


FIG. F.—Chart showing a sub-contractor's organization.

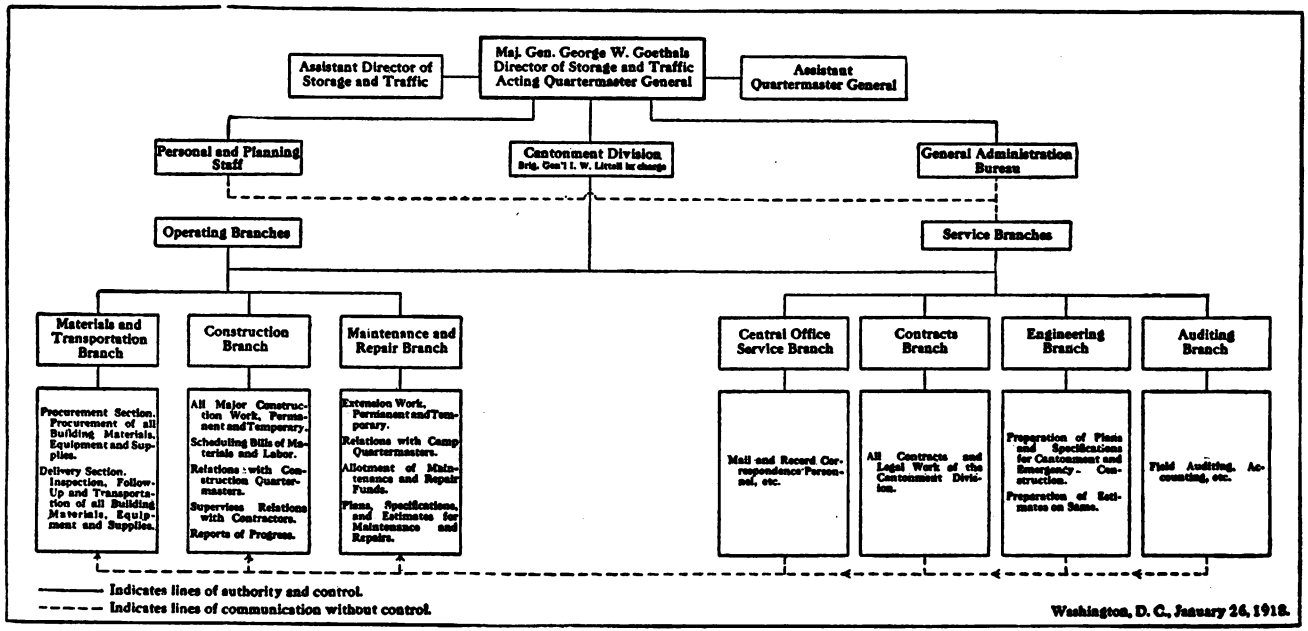

Assistant Director of Storage and Traffic
Maj. Gen. George W. Goethals Director of Storage and Traffic Acting Quartermaster General
Assistant Quartermaster General
Personal and Planning Staff
Cantonment Division Brig. Gen'l L. W. Littell in charge
General Administration Bureau
Operating Branches
Service Branches
Materials and Transportation Branch
Construction Branch
Maintenance and Repair Branch
Central Office Service Branch
Contracts Branch
Engineering Branch
Auditing Branch
Procurement Section. Procurement of all Building Materials, Equipment and Supplies.
Delivery Section. Inspection, Follow-Up and Transportation of all Building Materials, Equipment and Supplies.
All Major Construction Work, Permanent and Temporary.
Scheduling Bills of Materials and Labor.
Relations with Construction Quartermasters.
Supervises Relations with Contractors.
Reports of Progress.
Extension Work, Permanent and Temporary.
Relations with Camp Quartermasters.
Allotment of Maintenance and Repair Funds.
Plans, Specifications, and Estimates for Maintenance and Repairs.
Mail and Record Correspondence Personnel, etc.
All Contracts and Legal Work of the Cantonment Division.
Preparation of Plans and Specifications for Cantonment and Emergency Construction.
Preparation of Estimates on Same.
Field Auditing, Accounting, etc.
Indicates lines of authority and control.
Indicates lines of communication without control.
Washington, D. C., January 26, 1918.

FIG. G.—Cantonment division of the War Department expanded.

be handled in the same manner. The various departments are linked together by lines, showing how one department must work with another, and also how one may serve several different departments, as in the case of the material and transportation departments. The chart also indicates how the purchasing department links the material department to the bookkeeping, auditing and financial end of the organization.

Fig. F is the chart for a sub-contractor on a cantonment job. This, too, was devised by the author. The job involves the expenditure of about $50,000 of work and was carried on day and night. This chart was modeled after that shown in Fig. E, but is not so comprehensive.

In Fig. G, the organization chart of the new cantonment division of the quartermaster general is shown. This division of the War Department has built all the camps, is now building additional structures and new terminals, as well as maintaining and repairing the work already completed. This chart shows how operating and service branches can be co-ordinated.

It is the earnest hope of the author that, with the use of these charts, in connection with other diagrams given in this volume, the reader will be able to outline and organize his construction forces so that the work will be carried on with the least possible friction and waste of effort.

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